A MANUAL OF SURGICAL TREATMENT

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MANUAL OF SURGICAL TREATMENT.

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The Treatment of the Surgical Affections of the Pancreas, Liver and Spleen, the Genito-Urinary Organs, the Larynx and Neck, the Thorax and the Breast.

A Manual of Surgical Treatment

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NEW EDITION

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LEA & FEBIGER

PHILADELPHIA AND NEW YORK

1912

TO

THE RIGHT HON.

LORD LISTER, O.M., LL.D., F.R.S.

THE FOUNDER OF MODERN SURGERY
WITHOUT WHOSE WORK MUCH OF THIS BOOK
COULD NOT HAVE BEEN WRITTEN.

PREFACE

TO

REVISED EDITION.

SINCE the first edition of this work was published many changes have naturally occurred in the field of Surgical Treatment. Attempts have been made from time to time to incorporate the most essential of these in successive impressions, but it is always difficult to interpolate new matter of this kind satisfactorily without extensive revision of the entire work. It has therefore seemed best to revise the matter throughout and to alter in it whatsoever was necessary to bring it up to date. The original scheme of the work has been adhered to; to depart from it would have been to abandon the fundamental idea upon which it was based. Every part of the book, however, has been thoroughly revised, and a considerable part has been re-written.

The pressure of other work rendered it impossible for the original authors to undertake a task of such magnitude with any hope of being able to complete it within a reasonable time. In Messrs. T. P. Legg and Arthur Edmunds they have been fortunate in securing collaborators who have rendered their task possible, and to them they are under a great obligation. To their colleagues Dr. Silk, Dr. D'Este Emery, Dr. Arthur Whitfield and Mr. A. D. Reid, they are also much indebted for help in the several departments of treatment with which these gentlemen are specially concerned. Mr. Arthur Edmunds, in addition to his share in the revision, has provided a number of the new illustrations; Messrs. F. Butterworth and S. A. Sewell have drawn the remainder.

Messrs Down Bros., Allen & Hanburys, Barth, and others have kindly allowed the reproduction of many instrument blocks from their catalogues. Other figures have been reproduced by permission of their authors or publishers, and the source from which they are derived will be found duly acknowledged in the text.

LONDON, 1911.

AUTHORS' PREFACE

TO

THE FIRST EDITION.

THE subject of Surgery has now become so extensive that any work attempting to deal with it in an exhaustive manner must necessarily be so large and unwieldy as to be suitable only for purposes of reference, or for the use of those who devote themselves exclusively to its practice. In any text-book of convenient size the information given in certain branches of the subject must therefore be considerably condensed, and, as the first essential for the beginner is to have the fullest knowledge of the nature and characters of the diseases that he has to study, special stress is usually laid upon pathology, symptomatology, and diagnosis. For the practitioner, on the other hand, who is already acquainted with these points, the great essential is full and detailed information as to the best methods of treatment.

We have ourselves frequently experienced the want of detailed information, especially as regards the after-treatment of our cases, and have had to learn the best methods of procedure from experience. Nothing can of course replace experience, but it is often of the greatest advantage to have a detailed record of that of others upon which to base one's work. It is this want that the present work is intended to supply. We have tried to put ourselves in the place of those who have to treat a given case for the first time, and we have endeavoured to supply them with details as to treatment from the commencement to the termination of the illness. We have assumed that the reader is familiar with the nature and diagnosis of the disease, and we only refer to the pathology and symptoms in so far as it is necessary to render intelligible the principles on which the treatment is based, and the various stages of the disease to which each particular method is applicable.

We have purposely avoided attempting to give anything like a complete summary of the various methods of treatment that have from time to time been proposed: to do so would merely confuse the reader. Only those plans are described which our experience has led us to believe are the best, but with regard to these we have endeavoured to state exactly and in detail what we ourselves should do under given circumstances. In some cases no doubt several methods of treatment are of equal value, and while we have discussed at length that which we have ourselves been led to adopt, we have referred shortly to the others.

We have not mentioned all the exceptional conditions that may be met with, but we have endeavoured to include all the circumstances with which the surgeon is most commonly called upon to deal. The task has been one of some difficulty, the more so as we have had, to a certain extent, to break new ground. This must serve as our excuse for the many shortcomings in the work.

LONDON, *April*, 1899.

CONTENTS

OF

THE FIRST VOLUME.

DIVISION I.

INFLAMMATION AND ITS SEQUELÆ.

CHAPTER I.

INFLAMMATION.

CHAPTER II.

ACUTE SUPPURATION.

CHAPTER III.

ULCERATION.

CHAPTER IV.

GANGRENE.

DIVISION II.

WOUNDS AND THEIR COMPLICATIONS.

CHAPTER V.

WOUNDS.

CHAPTER VI.

MODES OF HEALING OF WOUNDS.

CHAPTER VII.

THE TREATMENT OF INCISED WOUNDS.

CHAPTER VIII.

PUNCTURED, CONTUSED, LACERATED, AND POISONED WOUNDS; BURNS, SCALDS, AND FROST-BITES.

CHAPTER IX.

INFECTIVE DISEASES OF WOUNDS.

CHAPTER X.

AFFECTIONS OF CICATRICES.

DIVISION III.

SYPHILIS AND TUBERCULOSIS.

CHAPTER XI.

SYPHILIS.

CHAPTER XII.

TUBERCULOSIS.

DIVISION IV.

TUMOURS.

CHAPTER XIII.

TUMOURS.

DIVISION V.

DEFORMITIES.

CHAPTER XIV.

DEFORMITIES AFFECTING THE FINGERS AND TOES.

CHAPTER XV.

FLAT FOOT.

CHAPTER XVI.

CLUB FOOT.

CHAPTER XVII.

CURVED TIBIA AND FIBULA.

CHAPTER XVIII.

GENU VALGUM: GENU VARUM: GENU RECURVATUM.

CHAPTER XIX.

CURVATURES OF THE NECK OF THE FEMUR.

CHAPTER XX.

CONGENITAL DISLOCATION OF THE HIP.

CHAPTER XXI.

KYPHOSIS: SCOLIOSIS.

APPENDIX.

ANÆSTHETICS.

By DR. J. F. W. SILK.

THE EXAMINATION OF THE BLOOD IN SURGICAL CONDITIONS.

By Dr. W. D'Este Emery.

ILLUSTRATIONS

TO

THE FIRST VOLUME.

DIVISION I.

INFLAMMATION AND ITS SEQUELÆ.

CHAPTER I.

INFLAMMATION.

DEFINITION.—Inflammation may be defined as the first series of changes that occur in a tissue as the result of an injury, provided that the latter has not been sufficiently violent to destroy the vitality of the part at once. When an injury is done to a part, whether the injury be chemical or mechanical in nature, a certain series of changes at once commences there, and this we call inflammation, so long as it is of an exudative or destructive character. The amount of inflammatory change in the tissue will depend upon the length of time that the process lasts, and the severity and result of the inflammation will be proportionate to the length of time that the irritant exerts its influence, and the intensity with which it acts. Inflammation is divided into two forms—acute and chronic.

ACUTE INFLAMMATION.

PATHOLOGY.—It is only necessary here to enumerate the changes that take place in the tissues after an injury.

Changes in the Early Stages.—In the first instance they consist of dilatation of the blood-vessels, preceded in some cases by contraction. This dilatation chiefly affects the small arteries and capillaries, but also to some extent the veins. The circulation of the blood is quickened, but slowing of the blood-stream soon becomes evident, and eventually complete stasis or coagulation of the blood takes place within the vessels at the focus of the inflammation in severe cases. During this period also, fluid collects in the surrounding tissues, which become much swollen. Probably this fluid is mainly derived from the blood plasma, but in part it is lymph retained in the tissues. Not only does fluid accumulate outside the vessels and coagulate there, but the white corpuscles pass out through the walls of the veins in large numbers, and also to some extent through those of the capillaries ; in certain inflammations also, red blood-corpuscles may escape from the blood-vessels. The inflammatory process may come to a stop at this stage, if the cause has ceased to act, and then the process known as *resolution* sets in, that is to say, the exuded material becomes broken up and removed by the lymphatic vessels, and the migrated corpuscles either re-enter the blood-vessels or the lymphatics, or break down and are carried away in the form of débris. The dilated vessels gradually regain their tone, and ultimately the part resumes its normal appearance and structure. In very severe cases, on the other hand, the stasis and exudation may be so great as to lead to gangrene of the part even at this early stage.

Changes in the Later Stages.—Inflammation that has gone on to this degree generally proceeds further, and the inflammatory process gradually brings about the disappearance of the original tissue which becomes replaced by what is known as *granulation tissue*, composed, in the first instance, of round cells and embryonic blood-vessels. When this stage of granulation is reached one of three things will happen. In the first place, the irritant may cease to act, in which case the inflammatory process subsides and retrogressive changes take place, in the course of which the cells composing the granulation tissue develop into fibrous tissue, and the blood-vessels diminish in number and become blocked by a process analogous to arteritis ; the ultimate result of this is the formation of scar tissue, and not restoration of the part to its normal condition, as is the case in resolution. In the second place, the process may end in suppuration if the cause of the inflammation be more persistent, as it usually is. In the third place, the result known as ulceration may follow, when the inflammatory process affects the skin or mucous membrane, and is not very violent.

SYMPTOMS.—We shall consider first the symptoms of the early stage ; these are partly local and partly general. The *local changes* are diffuse redness of the part, which is most intense at the centre, and swelling, which varies in character at different parts, being hard and brawny towards the centre of the inflammatory area and soft and œdematous towards its margins and which sometimes assumes large proportions. There is also heat and severe pain, usually of a throbbing character, which is worse when the inflammation affects dense tissues and when the part assumes the dependent position.

When the inflammation is due to a chemical or mechanical irritant, the symptoms are usually entirely local, with the exception of such slight constitutional disturbance as may be caused by pain and sleeplessness. When, however, the local irritation is produced by parasitic organisms, there are usually *general or constitutional symptoms* as well. These vary considerably in degree; in some cases they are trivial or absent, while in others they are of extreme severity. They are marked by a certain amount of fever and present two great types. The first type is commonly termed *sthenic* fever, and in it there is headache and anorexia, the temperature rising to 103° or 104°; the pulse becomes rapid, varying from 100 to 112, and is full, not easily compressible, but regular. The tongue is furred, white, and moist, the skin is hot and dry, the bowels are constipated, and the urine is scanty and high-coloured. Delirium of a noisy and violent character is often present; in fact, this form of inflammatory fever is characteristic of strong reaction, and the patient shows no marked depression. The second type, termed *asthenic* inflammatory fever, is met with in certain cases; the great characteristic of this type is marked depression of the vital powers. The temperature, as in the other case, is high, but the pulse is quicker and may run up to 130, and is soft, thready and easily compressible. The tongue is dry and brown, delirium, if present, is of a low muttering character, and the patient is generally in a semi-conscious state. The condition of the patient is in fact due to an acute septic poisoning (see p. 189).

TREATMENT.—This is best considered under the heads of local and general treatment. The great characteristic of the inflammatory changes is that they only continue as long as the cause which produces them continues to act; as soon as the cause ceases to act, they quickly come to a standstill, and then either resolution or retrogression, with or without scar-formation, takes place.

Removal of the Cause.—Hence, the first great question in the treatment of inflammation, is whether it is possible to remove the cause. The causes of inflammation will be discussed more in detail in connection with suppuration; but, as regards treatment, they may be divided into two classes—viz. those which are and those which are not readily got rid of. The removable causes are foreign bodies, chemical irritants, and the like; the irremovable ones are micro-organisms growing in the tissues, and they are, unfortunately, the more common. The action of these parasites, however, is to a certain extent dependent upon, or influenced by, various circumstances which favour their growth. Therefore, if any foreign body or other removable cause be present, it should be removed and if there be no cause that can be removed, an attempt should be made to put the tissues under the most favourable conditions to resist the growth of the parasite, and, moreover, anything which is aiding its development should be got rid of if possible.

Local Treatment.—The most obvious symptom in inflammation is the congestion of the part, and the first point in the local treatment of an acute inflammatory trouble in which the cause is irremovable, is to attempt to diminish this congestion as much as possible. If the congestion be diminished, the pain will be lessened also and the patient's general condition ameliorated.

Position.—When an inflamed part is allowed to hang down, the throbbing and the pain increase, as a result of the dilatation of the blood-vessels. The first essential in the treatment of acute inflammation, therefore, is to raise the inflamed part and, if possible, to place it on a higher level than the heart. By doing this the congestion is diminished not only by the mechanical emptying of the blood-vessels, but also by the production of reflex contraction of the arteries.

Blood-letting.—A second method, by which the congestion of the part may be relieved and the local symptoms considerably ameliorated, is blood-letting, which may be either general or local.

General blood-letting, or the removal of a relatively large quantity of blood from the general circulation without any special reference to the seat of the inflammation, probably acts by lowering the action of the heart, producing faintness, and so diminishing the circulation in the affected part. It is also possible that the loss of a considerable quantity of blood may alter the constitution of the remaining blood plasma to some extent, and render it more active as an anti-bacteric agent. General blood-letting was formerly much in vogue, but is seldom practised nowadays; it is best effected by opening a vein, the one usually chosen being the median basilic, on account of its large size and ready accessibility. The method, however, at the present time is almost entirely restricted to such inflammatory conditions of the lungs, and sometimes of the brain, as are characterised by engorgement of the right side of the heart.

Although this is a small operation, it is absolutely necessary to perform it with full antiseptic precautions, the patient's skin, the operator's hands, and the lancet being thoroughly purified in the ordinary manner;[1] in former times patients occasionally lost their lives from septic thrombosis. The patient sits upright upon a couch, so that he can lie down immediately, should he feel faint; this position has the further advantage that the patient will become faint sooner than if he were lying down, and thus a certain safeguard is provided against the withdrawal of too much blood. Venesection should never be practised with the patient in the recumbent position. A bandage is tied in a bow round the upper arm, tight enough to cause engorgement of the veins, but not to interfere with the arterial flow. The superficial veins are distended still further by making the patient grasp a stick, which helps to force the blood from the deep into the superficial veins. The surgeon faces the patient, grasps

[1] For the methods of disinfection of skin, instruments, etc., see Chap. V.

the arm with his left hand, and steadies the median basilic vein by placing the left thumb upon it immediately below the intended seat of puncture; then, with a sharp double-edged lancet, he makes an oblique incision through the skin and the anterior wall of the vein at one cut. The incision should cross the long axis of the vein a little obliquely; the posterior wall of the vein should not be divided. The blood flows in a steady stream from the vein, and is received into a graduated porringer. It is generally the custom to slip the left thumb over the incision in the vein as soon as it is made, so as to prevent bleeding until the porringer is in position.

The amount of blood usually withdrawn from an adult varies from ten to fifteen ounces, in the case of children from one to three. In former days the patient was bled until he felt faint or actually fainted, but bleeding to this extent is practically never employed at the present time. After a sufficient quantity of blood has been withdrawn, the bandage around the arm is removed and a small pad of gauze is placed over the incision, and kept in position by a few turns of a figure-of-eight bandage. This suffices to arrest the bleeding, and in a few days the wound will be healed and the circulation re-established. The patient should keep the arm in a sling for four or five days. Modifications in the operative technique may be necessary when the operation is performed in cases of pneumonia, heart disease, apoplexy or similar conditions; here the position of the patient and possibly other details must be arranged to meet the requirements of the individual case.

The operation is easy, but care must be taken not to allow the point of the lancet to penetrate too deeply, for the brachial artery has been punctured and an aneurismal varix has resulted. A vein which used to be frequently opened is the external jugular vein as it crosses the sterno-mastoid muscle, but here there is considerable risk of air entering the vein and causing serious danger to life. Moreover, the operation in this situation possesses no countervailing advantages in cases of inflammation, and therefore we shall not describe it.

The method most in vogue at the present day, however, is **local blood-letting**, which may be effected by the application of leeches, the use of cupping, or the employment of incisions or scarifications.

Several points require to be mentioned with regard to *the application of leeches*. The part to which the leeches are to be applied must be carefully cleansed, as otherwise they will not bite readily; the application of a little cream or milk to the skin may prove effectual in making them do so. When the leeches are put on the skin they should be confined until they have taken hold, and this may be conveniently done by inverting over them a pill-box or wineglass of suitable size; when they have fixed themselves this can be taken away. Special leech-glasses are employed for this purpose, and answer admirably; in using them it is necessary to see that the leech is put into the glass tail first (the thick end of the leech) and not head first; the mistake is not uncommonly made by students. A narrow test-tube answers the purpose of a leech-glass excellently. Leeches that have not been confined in this manner to the area to which it is desired to apply them have wandered into mucous canals, such as the rectum or the vagina, and have there caused considerable mischief.

When a leech has been applied, it is allowed to suck its fill, and the amount of blood which each individual leech will abstract varies from a drachm to a drachm and a half. When it has sucked as much blood as it will hold, it usually falls off, but its detachment can always be hastened, if necessary, by applying salt and water to it. The wound made by the leech is tri-radiate and does not extend deeply into the skin, and, therefore, were there no provision for preventing it, coagulation would occur, and very little blood would be obtained from the wound after the leech had detached itself. In the pharynx of the leech, however, there is a gland secreting a substance which prevents the coagulation of the blood, and it is probable that the cases of troublesome bleeding after the application of leeches are explained by the fact that this secretion has been left in the wound in considerable quantity.

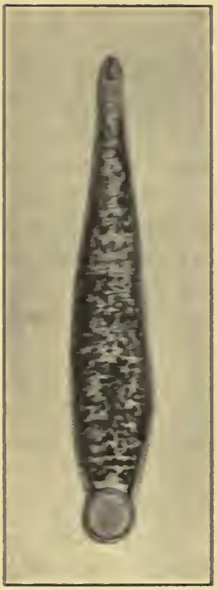


Fig. 1.—A Leech. The drawing is natural size, and shows the ventral aspect of the leech, with the head uppermost.

Bleeding from Leech-bites.—As a rule, bleeding from a leech-bite stops soon after the leech has been removed; in many cases indeed, fomentations have to be applied when it is desired to abstract more blood. Occasionally, however, there is considerable difficulty in arresting the bleeding. If a firmly applied pad and bandage should fail, the skin around the leech-bite should be pinched up, the bite carefully dried, and flexile collodion painted over it and allowed to dry before the pressure is relaxed; or a solution of adrenalin chloride (1 in 1000) may be applied in a similar manner and is very efficacious. Should this not be available, however, liquor ferri perchloridi may be applied. Should the bleeding persist in spite of this, the most effectual plan is to excise the leech-bite and suture the edges of the wound thus made; the object is to remove the tissues impregnated with the material from the leech's pharynx.

In view of the possible occurrence of troublesome hæmorrhage, it is not advisable to apply leeches to any region in which the skin cannot be compressed against a bone. For instance, they should not be applied to the scrotum; if leeching be required for an inflammatory condition in that situation, the leech should be placed on one side of the perineum, where pressure can be applied against the pubic bone. When leeches are required for affections of the eye, the best plan is to apply them over the temple where firm pressure can be easily applied, if necessary. The hair should be shaved from the spot to which the leech is to be applied, and the mark of the bite will be concealed when the hair grows again. It is also well to apply leeches early in the day, so that bleeding may be readily observed, as serious loss of blood has occurred through unnoticed continuous oozing through the night.

Another method of blood-letting employed in inflammation is cupping. For the purpose of actually removing blood, wet cupping is used, but in some cases a good deal of benefit is derived from the employment of *Dry Cupping*, which consists in applying the cups without previous scarification of the skin, and therefore without any loss of blood to the patient. If the special cup sold for the purpose be not available, a small tumbler will answer equally well. The edge of this is oiled, and a piece of blotting-paper, dipped in methylated spirit, is wedged firmly in the bottom of the glass, and set on fire with a match; if too small a piece be used, it may fall down and burn the patient's skin. When the paper has burned a few seconds the glass is inverted over the skin, which should have been sponged previously with warm water; as the heated air in the glass contracts on cooling, a partial vacuum is created, and the skin and subcutaneous tissues are drawn up into the cup, forming a prominent mass full of blood. Another method is the following: the edge of the cupping-glass is well greased and a few drops of spirit are poured into it. This is then lighted, blown out and relighted, the process being repeated until the vapour lights with a slight explosion. The cup with the lighted vapour is then rapidly applied, the flame is extinguished instantly and the vacuum formed. A number of cups may be applied in this way and left on until the swelling of the skin has increased to such an extent as to replace the air lost by the heat, when they become loose; should it be desired to remove them before this has occurred, it can be easily done by insinuating the finger-nail beneath the rim of the cup, so as to allow the entry of a little air.

When *Wet Cupping* is employed, the skin is first scarified in a number of places. This is best done with an ordinary scalpel, as the special instrument sold for the purpose is difficult to keep aseptic and in working order. The incisions should only go deep enough to draw a little blood; if the skin be cut through and the fat exposed, small pellets of the latter will plug the incisions and stop the bleeding. The object is to open as large a number of capillaries as possible. When the scarification has been done, the cup is applied directly over the scarified area as already described. The result is that blood is drawn out of the part until the place of the air is taken by the blood which issues from the skin; the cup then gets loose and can be removed. If required, further bleeding can be promoted by the application of warm fomentations, or the scarified surface may be sponged free of clots and the cup applied a second or even a third time; the quantity removed by each cup is from one to three drachms. The method is especially useful in the lumbar region, for renal affections. There is no trouble in arresting the bleeding.

In the method of local blood-letting by *Scarifications* the latter are made with a scalpel with the precautions already referred to in describing cupping. Scarifications are mostly used in cases of inflammation affecting mucous membranes, such as inflammation about the back of the throat; when there is œdema of the glottis much good may result from early scarification of the pharynx with a curved bistoury introduced through the mouth.

Free incisions into an inflamed part are often of great value in acute inflammatory conditions; they not only allow the escape of blood from the engorged blood-vessels, but also permit the escape of the exudation,

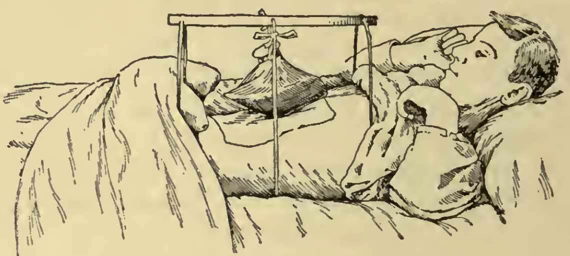


Fig. 2.—Method of applying an Ice-bag.

which might otherwise cause serious pressure upon the blood-vessels. This is more especially the case in inflammations in dense tissues, such as periosteum and bone, where the blood-vessels are confined within rigid canals, and where the pressure of the exudation in these canals may be so great as to obliterate the vessels, and so cut off the blood-supply to the bone. In early acute suppurative periostitis and osteomyelitis, it is imperative, if extensive necrosis is to be avoided, to make free incisions through the periosteum as soon as the nature of the affection has been diagnosed, and, in the case of osteomyelitis, to remove portions of bone so as to open up the medullary cavity freely.

Cold.—The local inflammatory phenomena may be diminished by the application of cold, which is supposed to act by contracting the arteries supplying the part, and so diminishing the flow of blood through it. But in severe inflammation, the vitality of the tissues may be so depressed by the prolonged application of cold, that actual death of the tissue may follow, and this is a danger which should be borne in mind. Cold also slows the circulation so that the blood becomes unduly venous, and thus also interferes with the nutrition of the part. Hence the use of cold should be limited to the early stages of inflammation, for it is hardly likely that it will arrest the process when much exudation has taken place, while in this stage the danger of weakening the tissue is especially great.

Probably the mildest method of using cold is in the form of an *Evaporating Lotion*.[1] A piece of lint is placed over the skin and kept constantly moist with the lotion, the part being freely exposed to the air to favour rapid evaporation; the patient can generally keep the lint moist for himself. Another favourite lotion is the liquor plumbi sub-

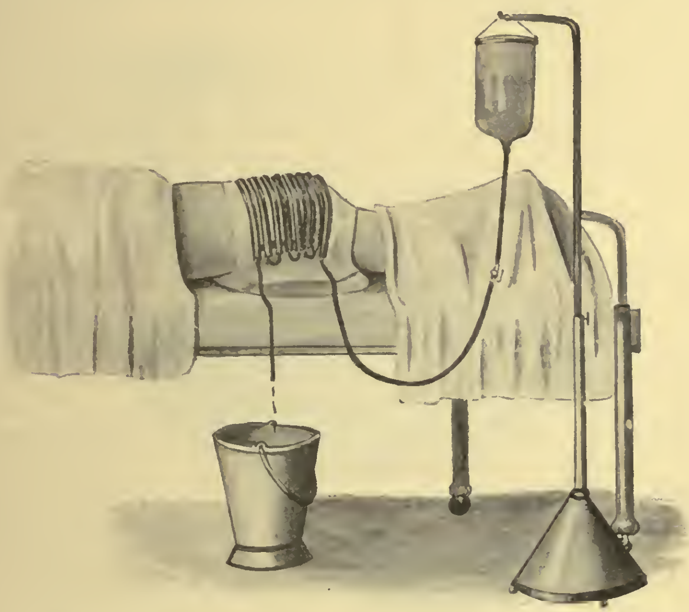


FIG. 3.—LEITER'S TUBES. The illustration shows the method of using the tubes by coiling them in a spiral manner around the limb.

acetatis dilutus (B.P.) used as described above. If there be much pain, 10 to 20 minims of tinct. opii may be added to each ounce of this.

If greater reduction of temperature be required, dry cold should be used, because the wet form is more apt to lead to gangrene than is the dry. Dry cold may be applied by means of an *Ice-bag*, crushed ice being placed in an indiarubber bag or a bladder suspended over the part so

[1] The following may be found useful :—

Ammonii chloridi	. ℥ss.	*Or,*	Ammonii chloridi	.	ʒss.
Spirit. vini rect.	. ℥j.		Aceti destillati	.	ʒj.
Aquam . .	ad ℥viij.		Spiritus rectificati	.	ʒj.
Misce. Ft. lotio.			Aquam . .	ad	℥j.
			Misce. Ft. lotio.		

that the weight of the ice does not cause pressure upon the inflamed area. A convenient plan is to tie the ice-bag to a bed-cradle, so that it just touches the part where cold is required. A piece of lint should be placed between the ice-bag and the skin to absorb the moisture (see Fig. 2). The ice will require renewal as it melts, and therefore the bag should be inspected frequently. The condition of the part should be carefully watched, and if the skin become dusky from excess of venous blood, or if the circulation in it be markedly slowed—as shown by pressing on the skin and watching the rapidity with which the vessels fill again—the use of cold should be abandoned.

Fig. 4.—Leiter's Tubes. This form is the best for use upon most occasions. The tubes are coiled upon and fixed to a light flexible metal plate, and hence are not likely to become kinked or to leak. The metal plate is moulded to the surface and secured by tapes, a fold of lint being interposed between it and the skin.

A still more effectual way of employing cold is by means of *Leiter's Tubes,* which consist of fine lead tubing twisted into a flat spiral coil and then moulded so as to surround the part without causing any undue pressure. Through this a constant stream of water is passed, and any required degree of cold can be obtained according to the temperature of the water. Between the tubing and the skin a piece of lint should be placed (see Figs. 3, 4).

Intense cold may be produced by these tubes, and it is seldom advisable to leave them on an acutely inflamed part for more than twenty-four hours at a time. The condition of the circulation should be noted every three or four hours. The tubes are more useful for arresting bleeding or relieving great engorgement of the part than they are in inflammation. When used for the latter purpose, the temperature of the water circulating through them should range from 50° to 60° F.; when used to arrest bleeding, the temperature may be as low as 33° F.

Heat.—When an acute inflammation has lasted for two or three days, cold is no longer of benefit and may even cause damage; under these circumstances the application of heat is more likely to be beneficial. It soothes the inflamed nerves, causes dilatation of the vessels, and, by increasing the flow of blood, brings more of the anti-bacteric agents into the part.

Heat may be applied to the skin over an inflamed part, by means of poultices or hot fomentations. A *poultice* is usually made with about four tablespoonfuls of linseed meal to half a pint of water. It must not be too heavy and, as it loses its heat very quickly, special care should be taken to see that the bowl in which it is mixed, and the material on which it is spread, are well warmed previous to use. The poultice should be made as quickly as possible, and applied as hot as the patient can bear it. The linseed meal is well stirred into the boiling water so as to ensure that it is of a soft even consistency free from hard lumps or masses. When mixed, the mass is turned out upon a piece of linen, previously warmed, and large enough to extend two inches all round beyond the poultice, and upon this it is spread with a spatula in an even layer about half an inch thick. The edges of the linen are then turned up around the margins and the poultice is ready for use. The whole operation should be carried on before a good fire. After the poultice has been applied, a layer of well-warmed wool is placed outside it, and the whole is fixed on with a bandage. A poultice generally retains its heat for about two hours, and should then be changed; when it is removed, the skin should be dried and gently chafed with a soft warm towel, and covered with a blanket until the fresh poultice is ready. Unless the precaution of covering up the patient be taken, the part becomes chilled, and all the good of the poultice may be undone.

There are various advantages and disadvantages in the use of poultices as compared with fomentations. Poultices retain the heat longer, and therefore it is not necessary to change them so frequently as fomentations, while, on the whole, they are considerably warmer. The chief objection to their use arises in connection with cases in which a surgical operation will be necessary subsequently. It is difficult to purify the skin effectually after a poultice has been used, for the latter is a decomposing vegetable substance, which soaks into the hair follicles, the hairs, and the epidermis. Hence, when an abscess is likely to form, and when surgical interference may therefore be required, it is well to employ fomentations instead of poultices. Various antiseptics have been mixed with the poultice in order to render it aseptic. Charcoal, which is sometimes employed, is simply a deodorant, and possesses no true antiseptic properties. Boric acid or carbolic acid is also sometimes mixed with the poultice. Probably the best mixture is one of linseed meal and eucalyptus oil, but none of them are satisfactory from the antiseptic point of view, and hence, when an operation is likely to be required, fomentations should be substituted for poultices, at any rate for some time beforehand.

When making *fomentations*, the precautions against loss of heat must be attended to even more carefully than in the case of poultices. A fomentation consists of a piece of flannel wrung out of boiling water and covered with mackintosh and a mass of wool, and the great point in its preparation is to apply it as hot as possible. A mass of wool considerably larger than the flannel should be placed in readiness before a brisk fire, and on the top of that should be placed a piece of mackintosh with the mackintosh side outwards, and large enough to overlap the flannel in all directions. A well-warmed basin is then taken, a dry towel is placed over it, and in the centre of this towel a piece of flannel of suitable size folded in two or four thicknesses is laid. Boiling water is poured over the flannel, which is then squeezed as dry as possible by twisting up the ends of the towel rapidly ; no water must be left in the flannel lest the patient be scalded. The folded flannel is then quickly shaken out and placed on the top of the mackintosh, and then the whole mass—wool, mackintosh, and flannel—is lifted up and applied rapidly to the affected part. As soon as the patient can bear it, the whole is fixed on with a binder or bandage.

FIG. 5.—WRINGER FOR PREPARING FOMENTATIONS.

When a number of fomentations have to be applied the apparatus shown in Fig. 5 is very convenient. It consists of a short jack-towel slung on two pieces of broomstick. The flannel is placed between the two layers of the towel, and the sticks brought together so that the towel and flannel hangs down between them and can be dipped in boiling water. By twisting the sticks in opposite directions the flannel can be wrung out very thoroughly. The fomentation will usually require to be renewed in from half an hour to an hour, but it may be kept warm longer by placing an indiarubber hot-water bottle outside it, if the patient can bear the pressure. When renewing the fomentations, a warm towel must be at hand, with which the skin is at once dried and chafed when the fomentation is taken away, and this towel is left *in situ* while the fresh one is being prepared. When there is severe pain, much relief may be afforded by sprinkling half a drachm or more of laudanum on the surface of the fomentation after it has been prepared; the laudanum should be previously warmed by immersing the bottle in hot water. When the inflammation is deep-seated, and a certain amount of irritation of the skin is desired, this may be obtained by sprinkling ten to twenty drops of turpentine over the surface of the flannel, and thus making what is known as a *turpentine stupe*. *Antiphlogistine* is a very satisfactory substitute for a fomentation in some cases.

A special material, known as *spongiopilin*, is sold to take the place of mackintosh in the fomentation. It consists of thick felt covered on one side with an impermeable layer, and is employed in the same way as the flannel in making the fomentation. As a rule, however, it is well to place mackintosh and wool outside the spongiopilin, as in an ordinary fomentation.

Bier's Treatment.—Recently a method of treatment has been introduced by Prof. Bier of Berlin, which is of great help in suitable cases. The essential point in Bier's treatment consists in the production of a localised hyperæmia. This may be obtained in several ways, and is either venous (passive) congestion, arterial (active) congestion, or a combination of both.

In the first of these—the method of *passive congestion*—an elastic bandage is applied between the inflamed part and the heart, sufficiently firmly to impede the venous circulation without affecting the arterial to any appreciable extent. The bandage employed is of thin indiarubber about two inches wide, and in some cases is applied next to the skin. In many instances, however, it will be found advisable to surround the part with wool or lint before applying the bandage, so as to avoid injury to the skin from pressure. When the bandage has been properly applied, the parts beyond become purplish in tint, and the superficial veins are engorged; the bandage should never be so tight as to cause pain. Cases are described in which the limb beyond the bandage has become white and œdematous—a condition known as white stasis—but this indicates either that the bandage has been improperly applied, or that the case is unsuitable for this treatment. This method of procuring passive congestion is only applicable to the limbs. In the case of the shoulder-joint a special arrangement must be employed. It has not been found possible to treat the hip-joint by this method.

The second plan—the method of *arterial congestion*—is carried out by directing a stream of hot air on the part, or by the application of local hot-air baths. For the latter method, a number of specially constructed chambers with heating arrangements have been devised. The result is much the same whether these be heated by electric lamps, by a coil of wire with a high electrical resistance, or by gas or oil-flames, and, apart from the question of price and convenience, there is little to choose between the many forms of apparatus on the market. The hot-air bath is administered daily, the temperature employed being often 200° F. or even more.

The bath usually lasts from half an hour to one hour. In all probability, poultices and hot fomentations act in the same way as this method.

Combined arterial and venous hyperæmia may be produced by the suction method, in which the affected part is placed in a partial vacuum. This is usually effected by means of a glass vessel joined to the limb by a tight indiarubber collar, and exhausted—either by an ordinary air-pump or by a syringe—until a vacuum equal to two inches of mercury is produced. The suction method has distinct advantage in some cases; for example, in dealing with sinuses, not only is congestion produced, but the pus is removed efficiently (see Fig. 6). The actual details of the application of the method to special cases will be explained in connection with the diseases in question. The mode of action of Bier's treatment is not quite clear, but the most recent view is that by increasing the circulation of blood and lymph in the part, it floods the latter with serum

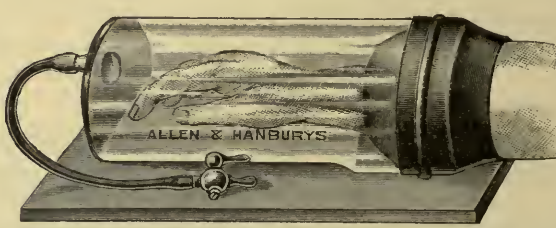


Fig. 6.—Bier's Suction Apparatus applied to the Fore-arm. The limb is placed inside the glass vessel and an air-tight junction is made by means of a rubber collar. The air is then exhausted through the tube.

containing opsonins, which render the bacteria vulnerable to the phagocytic elements of the body.

General Treatment.—This should be directed partly to relieving symptoms such as pain, and partly to promoting the excretion of the toxins absorbed into the blood from the inflamed area. With the latter object attempts are made to dilute the toxins in the blood by giving diluent drinks, and also to assist the secretions from the skin, the bowels, and the kidneys.

Purgatives.—In a case of inflammatory fever, it is important to administer a purge without delay; among the best is sulphate of magnesia or some other saline. Half an ounce or more of the sulphate of magnesia is given dissolved in a little water; the more concentrated the solution is the better is its effect. At least one copious watery evacuation daily should be thus ensured. The purge clears out decomposing material from the intestine, and should be given even when the bowels have been previously acting quite regularly. It also causes transudation of a quantity of water from the blood, and thus possibly removes a certain amount of the toxins. At the same time, it probably acts also as a counter-irritant, and thus exerts a further beneficial effect.

Drinks.—The patient should drink large quantities of fluid, with the view of diluting the poison in the blood, and of promoting its rapid elimination by the kidneys. Four to six pints of milk should be given daily if the patient can take it. The combination of milk with barley-water is good, as the latter prevents to some extent the constipating effects of the milk; it also retards coagulation. If the milk curdles in the stomach, lime-water may be added, or still better, one-half to one drachm of the liquor calcis saccharatus to each tumblerful of milk. The patient should be also encouraged to take fluid drinks containing bicarbonate of potash or spirit of nitrous ether.[1]

These methods cause the kidneys to act without any undue irritation. Irritating diuretics must be carefully avoided on account of the tendency to albuminuria and nephritis in many of these acute inflammatory affections.

Drugs.—Drugs are of little advantage at this stage, but at night Dover's powder (gr. 10) may be given, partly to obtain sleep and freedom from pain, but mainly to promote the action of the skin. The latter object may also be furthered by giving liquor ammoniæ acetatis in two- to four-drachm doses every three or four hours.

Food.—The food should be fluid, essentially milk, with beef-tea occasionally; it is well to administer the food about every two hours—a tumblerful of milk alternating with a cup of beef-tea or some form of meat extract. An excellent nutritive broth can be made by adding to each cupful of bouillon a teaspoonful of finely grated meat. During the period of recovery, nourishing diet should be given, with stimulants and tonics, especially iron.

PROGNOSIS.—The prognosis of acute inflammation depends on its nature and seat. Should an acute inflammation, of the degree of which we have been speaking, last for more than three or four days, suppuration will almost certainly take place. If, on the other hand, the inflammation be subsiding, wrinkling of the skin will be noticed, and when this occurs, a favourable prognosis as regards suppuration may be given. This is not invariably the case, since wrinkling of the skin may be met with in the vicinity of an abscess, owing to the subsidence of the œdema.

[1] A very good one is that used in most hospitals, and called 'imperial drink'; it consists of one to one and a half drachms of cream of tartar added to a pint of boiling water, and then allowed to cool, a little sugar being added to sweeten it. The cream of tartar may also be conveniently given in gruel, made by adding a tablespoonful of oatmeal and about a drachm of cream of tartar to half a point of water, and boiling it, adding afterwards a tablespoonful of brandy and a little sugar. Another excellent diuretic drink can be made by adding half an ounce of phosphate of soda to an ounce of water flavoured with a little lemon-juice.

CHRONIC INFLAMMATION.

PATHOLOGY.—The process of chronic inflammation is somewhat difficult to understand and explain, because it generally forms a part of some other morbid process, and it is not easy to separate one from the other. It may begin as an acute inflammation, in which the symptoms do not entirely disappear, but gradually become less acute until the affection passes into the chronic form; on the other hand, the inflammation may be chronic from the commencement. The essential feature in chronic inflammation is the predominance of changes in the cellular tissues over those in the vascular and lymphatic channels which are observed in acute inflammation. In addition to the increased vascularity of the part similar to that seen in acute inflammation, a tissue which is the seat of chronic inflammation contains in abundance cells derived not only from the blood itself, but also by a process of multiplication from the endothelium of the blood-vessels, lymphatic vessels, and in part from the fixed connective-tissue cells themselves. These cells—fibroblasts, plasma-cells, mast-cells—all contribute to the formation of young fibrous tissue, which may be collected into one scar-like mass, or may be spread out between the cells of an organ—such as a gland—where they may cause destruction of the cells of that organ by a process of mechanical compression and deprivation of blood. The latter type of chronic inflammation, which is well seen in the syphilitic affections of the liver and testis, is known as fibrosis. The presence of these cells affords valuable aid in distinguishing between inflammatory and malignant growths, as they stain very characteristically by methods such as that of Pappenheim (see p. 18).

A chronically inflamed tissue never undergoes suppuration of itself. The so-called suppuration occurring in a part which is the seat of chronic inflammation is due either to acute septic infection, or to the liquefaction of the morbid material which is causing the inflammation; the latter is especially the case in tubercle. A typical chronic abscess, which has not been acute at the commencement, is practically always tuberculous.

CAUSES.—Like the acute form, chronic inflammation depends upon the *continued* action of some exciting cause, but the causes which produce chronic inflammation are not of the same violent nature as those which set up the acute form.

The most common cause of chronic inflammation is the presence in the tissues of some morbid material, such as the specific virus of one of the chronic infective diseases—notably, tubercle and syphilis; and it is well to bear in mind that in these cases, especially in tubercle, the main part of the swelling in the affected area is due not to the mass of tuberculous tissue, but to the chronic inflammation which its presence has set up.

Among other causes of chronic inflammation may be mentioned the presence of a foreign body; for example, a bullet embedded in the tissues, provided that it has not carried in with it any pyogenic organisms, will set up chronic inflammation in the part, which may last for a considerable time after the lodgment of the foreign body. Any obstruction to the free exit of secretion from a gland, as for instance a stricture or a calculus in its duct, brings about retention of the secretion behind the obstruction, and this leads to a chronic inflammation in the gland, which will continue until the obstruction is relieved, or until the gland undergoes atrophy; these cases, however, are often complicated by the presence of a mild septic infection. Chronic inflammation not infrequently results also from pressure, and ends in the formation of a quantity of new tissue, as is seen for example in callosities, which, forming in a part, subject it to much pressure. Then, again, various deposits from the blood are responsible for exciting a state of chronic inflammation; for example, in gout the deposition of urates in the tissues keeps up a condition of chronic inflammation in the neighbourhood of the deposit. In some cases, chronic inflammation seems to be dependent on certain states of the blood, the precise nature of which is not evident; an example of this is seen in rheumatism, where chronic inflammation of fibrous tissues often occurs, and may continue for a long time.

SYMPTOMS.—The most characteristic symptom of chronic inflammation is the presence of swelling, which is due to the formation of new connective tissue; thus, for example, a bone which is the seat of chronic inflammation may become enormously thickened. In organs in which there is much soft tissue, such as the liver, the final result of a chronic inflammation may be actual diminution in size, the new connective tissue formed undergoing contraction, and leading to atrophy of the normal cells. In most cases, however, swelling is a prominent feature. Of the other symptoms, the pain varies with the situation and is often slight, although in bone it is a marked feature, owing to the compression of the nerves by the exudation in the unyielding tissues. Some tenderness and heat are almost always present. The increased vascularity of the tissue is often evidenced by the enlargement of the veins on the surface of the swollen part. Constitutional symptoms are not present as a rule; if they are, it is either because some vital organ is affected, or because they are due to the disease which is setting up the inflammation.

In many cases the diagnosis can be cleared up by the microscopical examination of an excised fragment of the swelling. The presence of cells, such as Unna's plasma-cells, in considerable numbers is highly suggestive of the inflammatory nature of the swelling. Plasma-cells occur in normal connective tissue and to a certain extent in the stroma of malignant growths, but usually only in comparatively small numbers, and in these cases their presence or absence should always be ascertained by staining by Pappenheim's[1] or some allied method. None the less, the microscopical diagnosis between an inflammatory swelling and a new growth is often extremely difficult to make.

TREATMENT.—The first point in the treatment of chronic inflammation is to ascertain whether or not we can **remove the cause**, for if this be done effectually, the inflammation will subside at once. Thus, when a foreign body, such as a bullet, is embedded in the tissues, the indication is to cut down and remove it. Similarly, when the chronic inflammation is caused by obstruction of a duct, this must be remedied; when it is due to a deposit from the blood, as in gout, or to some state of the blood, as in rheumatism, appropriate medicinal treatment must be adopted for the elimination of the noxious material from the circulation. Most commonly, however, the cause of the inflammation is the presence of some chronic infective disease, and it is not always easy to get rid of this completely, especially when it is of a tuberculous nature. When it is not possible or advisable to remove the cause, various measures must be adopted which are calculated to diminish the inflammation; these measures are essentially local.

Local Treatment.—**Rest.**—The first essential point in the local treatment, after the question of removal of the primary cause, is to secure complete physiological rest of the part, and this is absolutely necessary for the subsidence of the inflammation. If the seat of the inflammation be a joint, this should be fixed; if it be a part affected by muscular movements, rest must also be obtained, the patient, if possible, being in bed with the part elevated. It has already been pointed out that the **position** of the part affects the congestion, and in chronic as in acute inflammation, relief of the congestion by means of the elevated position is an essential element in treatment. Even when it is impossible to remove the exciting cause (*e.g.* tubercle), much good may be done by methods calculated to diminish the inflammation itself, because inflamed tissues are more easily invaded by the morbid process than healthy ones; if the chronic inflammation can be diminished, extension of the primary disease may thereby be checked.

Counter-irritation.—By counter-irritation is meant the application

[1] The stain should be prepared fresh: a convenient method is the following. The dry stain is picked up on the point of an ordinary small blade of a pen-knife so as to cover about a quarter of an inch of the blade. Four times this quantity of pyronin and twice the quantity of methyl-green are dissolved in half a test-tube of distilled water, boiled and filtered hot on to the section. The stain is allowed to act for five minutes. A ten-per-cent. alcoholic solution of resorcin is then poured on to act as a mordant, the excess stain is removed from the section by absolute alcohol and the specimen is cleared in xylol and mounted in Canada balsam. The degree of differentiation can be watched conveniently while the specimen is in xylol, and if it is incomplete more alcohol can be used. The purple nuclei of the plasma-cells and their brilliant red cytoplasm distinguish them sharply from other cells.

of an irritant to some superficial part of the body, usually the skin, either over the seat of the inflammation or at a little distance from it; the application should be made to a part which is in intimate nervous connection with the inflamed area. It is not clear how benefit results from irritation of the skin; probably the irritant acts through the nervous system. Poultices and fomentations, which are of such value in acute inflammation, probable owe their virtue partly to the principle of counter-irritation, and they may be classed as the mildest counter-irritants with which we are acquainted. In chronic inflammation, however, some more active agent is usually necessary.

Mustard is one of the mildest counter-irritants in common use, and is employed either in the form of mustard-leaves or as a plaster. The mustard-leaves, which only require damping before being applied, are very handy and cleanly, and are generally used when counter-irritation alone is required. As a substitute for them, the ordinary mustard-plaster, made by mixing mustard into a thick paste with tepid water and spreading it on a piece of linen or brown paper, may be employed. The length of time that either of these preparations should be left on is determined by the patient's sensations. Ten to twenty minutes is generally sufficient; if left on longer they are apt to blister. Special care should be taken not to leave them too long on young children, in whom they may produce actual sloughing.

If the warm poultice action be required in addition to the counter-irritation, a mustard-and-linseed poultice may be employed. The poultice is made with boiling water in the ordinary way (see p. 11), one part of mustard being added to four parts of linseed meal. If a more energetic action be required, an ordinary linseed poultice is made, and mustard is dusted thickly over its surface.

The most popular method of producing counter-irritation is by the use of *tincture of iodine* or of *linimentum iodi*, the part being painted with the iodine every day until the skin becomes so sore that the patient cannot go on with it. As a rule, however, the effects of iodine are not satisfactory, and in many cases of tuberculous glands, in which it is so commonly used, it is positively harmful, as it tends to bring about suppuration. The two most potent agents in producing smart counter-irritation are blisters and the actual cautery.

Blisters may be produced either by the emplastrum cantharidis (B.P.) or by the liquor epispasticus. The part to which a blister is to be applied should be thoroughly cleansed, and if necessary, shaved. In an adult the plaster should be left on for about ten hours; the length of time required for the production of a satisfactory effect varies, however, with the thickness of the skin. In children, and in parts where the skin is thin, about five or six hours will generally be sufficient; on the other hand, where the skin is thick, as on the palm or the sole, it may even require twenty-four hours. When the plaster is removed, a good-sized blister is generally found beneath it; sometimes, however, the skin is merely reddened, or a few small vesicles only are present. In these cases the subsequent application of a fomentation or a poultice will facilitate the formation of the blister. If a drop or two of croton oil be rubbed over the surface of the plaster before application, its effect will be considerably enhanced. If, however, the blister does not rise properly in the course of a few hours, painting the skin with the liquor epispasticus and allowing it to dry will usually produce a satisfactory result. Some prefer the liquor epispasticus alone, painting it over the part two or three times in succession and allowing it to dry between each application. It must be freshly prepared, as otherwise it is very uncertain in its action.

Emp. cantharidis must not be left on too long for fear of causing sloughing of the skin, and the danger that the patient runs of absorbing the drug must be borne in mind; should this happen, there is considerable risk of nephritis. Blisters should not be applied, therefore, over large areas covered by thin skin, and should not be used at all when there is any renal disease. When the inflammation is still active and is affecting the skin or the subcutaneous tissues, the blister should not be applied immediately over the seat of disease, lest it should increase the congestion of the part, and thus augment the inflammation; it is better to apply it some little distance away. When the inflammation is subsiding, however, there is not the same objection to applying it directly over the affected area; on the contrary, the increased flow of blood and lymph which is thus set up may be very beneficial. When the inflammation is deeply seated, the best effect is usually got by applying the blister directly over the spot.

The *actual cautery* is a most potent means of producing counter-irritation, and is used either to form one large sore or a number of small ones; the former is probably the more effectual method. In spinal disease, for example, the production of a superficial sore three inches in length and two in breadth, on each side of the spine, will often do much good. Similarly, in hip-joint disease, two sores, one in front and one behind the joint, will often relieve the acute starting pains from which the patient suffers. Only the superficial part of the skin should be acted on, as it is important that the whole thickness should not be destroyed. In order to produce these large sores effectually, and without too much destruction of tissue, it is best to use a flat, iron cautery under anæsthesia (see Fig. 7). The cautery must be at a bright red heat, for otherwise it is difficult to gauge the amount of destruction of the skin produced. When a cautery is thus used, it suffices to rub it quickly two or three times over the part in order to produce the desired amount of burning. It is only necessary to destroy the epidermis and portions of the rete mucosum, and thus lay bare a large number of the nerve-endings. After the cautery has been applied, poultices or hot fomentations should be used until the slough separates, which will occur in four or five days. If now the wound were left to itself, or merely dressed with some simple ointment, it would heal with great rapidity, because the skin has not been deeply destroyed, and there are numerous points from which epithelium would quickly spread over the part. In order to get the best effect from the actual cautery, it is necessary to keep the sore open for a few weeks, and this can only be done by the application of some irritant to the sore after the slough has separated. Savin ointment is usually employed for this purpose, but many patients are unable to bear the pain caused by the pure ointment for any length of time, and in most cases it is necessary to dilute it with an equal part of simple ointment, to add about 5 to 10 per cent. of cocaine, eucaine, or novocaine, or to sprinkle the part with orthoform. Even when savin ointment is used, healing is often too rapid, and it may be necessary to destroy the young epithelium on the surface of the sore from time to time with nitrate of silver, or, if that does not suffice, to apply potassa fusa.[1] It is remarkable how quickly the pain, even when severe, disappears after the application of the cautery, and how it will often recur if the wound be allowed to heal too rapidly.

FIG. 7.—FLAT CAUTERY. The flat surface is generally used, but the edge can be employed if it be desired to score lines upon the skin.

Another form of cautery is that known as *Corrigan's cautery*, or the *button cautery*. This is a small, round, metal button fixed in a handle. It is heated to a red heat and pressed for a moment on the part; by it a number of little sores can be produced. The effect of this small cautery, however, is not so good as that of the larger one, at any rate in extensive inflammation of bone. When this cautery is not at hand, a similar effect can be produced by the broad blade of a Paquelin's cautery.

The *Paquelin cautery* is very useful when a milder effect is required. The broad platinum point is heated to a bright red or a white heat and then lightly and rapidly drawn across the skin so as to produce a series of parallel lines. Another set is then made crossing these at an angle so that there is a sort of 'cross hatching' over the desired area. If the cautery be white-hot, and applied rapidly enough with a sort of flicking motion, this operation is practically painless and no anæsthetic is required. The after effect is to produce a sensation similar to that of a mustard plaster. There is no need to apply any dressing if the cautery be applied in this way, as there is no injury to the deeper parts of the skin, the cuticle alone being charred.

Free incision into the part, removing if possible a piece for

[1] A stick of potassa fusa is held in a pair of forceps and rubbed quickly over the part, which is then covered with lint steeped in vinegar.

microscopical examination, is of the utmost value in many cases of chronic inflammation. For example, in chronic periostitis there is nothing that relieves the pain and improves the condition so much as a free aseptic incision; the effect of this is much increased if the thickened periosteum be taken away at the same time. Similarly, in chronic osteitis the best method of treatment is to gouge away a large portion of the inflamed bone. Even although the whole of the affected area be not removed, the rest very soon improves, and the patient is much relieved, and often cured. It must not be forgotten that free incision plays a dual rôle in many doubtful cases simulating chronic inflammation; it may be curative, but in any case it is of great value in diagnosis. Knowing that free incision into a chronically inflamed part is one of the best means of treating the

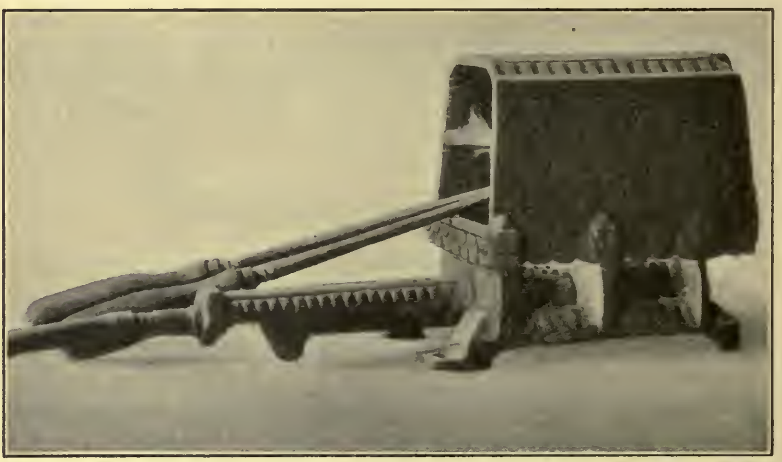


FIG. 8.—GAS STOVE FOR HEATING CAUTERIES. This is an ordinary soldering stove which will raise the cauteries to the desired temperature in a very short time.

inflammation, there need be no hesitation in ascertaining the true state of matters by making a free incision. Should it turn out that there is a tumour, the diagnosis is made, and the surgeon can treat the case as is required. On the other hand, should the case prove to be one of chronic inflammation, the most effectual steps have been taken to cure the patient.

Pressure in cases of chronic inflammation, is mainly of value when the process is subsiding; if it be applied when the inflammation is active, it is apt to increase the latter instead of diminishing it. When, however, the inflammation is subsiding, pressure is most valuable; in cases of thickening of the epididymis after acute epididymitis, for example, strapping the testicle is the favourite and best method of treatment. Pressure is also frequently employed for chronic inflammation of joints, whether due to tuberculosis or not. The essential point in employing pressure is that it should be equable and not too great; an excellent way to obtain it is to surround the part with a large mass of cotton-wool or silk waste in even sheets or layers, and then to apply a bandage over this as tightly as possible. Some starch or silicate of soda solution should be rubbed into the bandage to prevent it from becoming loose. This method is particularly applicable to cases of joint disease. An elastic bandage may be applied lightly outside the wool. Pressure may be also applied by means of *Scott's dressing*, which combines pressure with counter-irritation, and is most useful in joint diseases. Compound mercury ointment (*unguentum hydrargyri co.*) is spread upon chamois leather which is cut into strips and applied firmly, like other forms of strapping, in imbricated layers around the diseased part. Outside this a layer of cotton-wool is applied and bandaged on firmly; the limb is then placed upon a splint. Scott's dressing may be applied more economically by spreading the ointment upon a large piece of lint, which is then cut into strips, and these are applied to the limb in the usual imbricated layers. Outside these, ordinary strapping is applied in a similar manner; a splint is not always necessary. The part should be shaved before the strapping is applied, and the dressing should be renewed every four or five days, both because the skin is apt to become raw, and also because the strapping slips and the dressing becomes loose.

Massage is chiefly of value when the chronic inflammatory process has come nearly to a standstill, and it is a question of causing absorption of the inflammatory products. Massage employed during the active stage is apt to make matters worse. The essential principles of massage are first to break up the products of the chronic inflammation, and then to promote the absorption of the broken-up materials by the lymphatic vessels. There are various ways of breaking up the new material; the mildest form is termed 'friction massage,' and in it the part is rubbed in a circular manner with two or three fingers of one hand for some time, and then the material is forced into the lymphatic vessels by an upward uniform pressure, called 'effleurage.' In effleurage, the part which has been subjected to the friction is grasped with the whole hand, and is firmly and gently squeezed in an upward direction. This is repeated a number of times, when the friction is resumed, and again the effleurage follows. When the material is more difficult to break up, another action, called 'petrissage' or firm kneading of the part, is resorted to. The part is grasped between the fingers and the thumb, and is firmly kneaded; after the kneading, the broken-up products are forced into the lymphatics by effleurage. When the material is still more dense, and especially when it is limited to a small area, the action of 'tapotement' is employed; in this the part is firmly tapped, either with the fingers or a special instrument, and, after repeated and violent tappings as hard as the patient can bear, effleurage is again carried out. At first, massage should be very gentle, but the more forcible measures may be adopted as the patient becomes accustomed to it. As a rule, a daily sitting of twenty minutes is sufficient; but there may be two sittings daily, morning and evening, after three or four days, if distinct benefit results, and the length of the sittings may be increased to three-quarters of an hour or an hour as time goes on. The length of time required for a cure depends entirely on the nature of the case and the progress made; except in extensive and obstinate cases, three weeks generally suffice. Massage is especially useful after inflammations which cause adhesion either between muscles, or between tendons and their sheaths, or in joints or in any situation in which much thickening is left after inflammation or injury.

An efficient substitute for ordinary massage can be found in what might be called *automatic massage*. For example, in a sprain of the ankle it is often a good practice to strap the joint firmly. If the strapping be confined to the immediate neighbourhood of the joint, it will be productive of nothing but discomfort; the limb will swell around the strapping, which will cut into the leg, and may give rise to unpleasant sores. If, however, the strapping be carried well beyond the joint on both sides —in the ankle, for example—from the base of the toes to the knee, so as to encase the whole of the leg and foot in a comparatively rigid shell, every movement of the muscles will squeeze the lymph and venous blood from their interstices, and the extension of the strapping up the leg will carry the effusion into the region where the vascular and lymphatic arrangements are normal. The strapping should be carefully applied in narrow strips about an inch wide, overlapping about one-third of their width, and the limb should be shaved before strapping. With a strapping applied in this way, there is no necessity to confine the patient to bed or the couch; indeed, it is only by using the limb that the strapping can exert its proper effect, for the massaging action can only take place when the muscles within the casing are moving and altering in shape. The patient, therefore, should be allowed to use the limb freely. Over-use is harmful, but the presence of the strapping is in itself usually sufficient to restrain the patient from this indiscretion.

General Treatment.—In chronic inflammation the constitutional treatment depends rather on the disease which is the cause of the process than on the process itself. It is essential that the patient should be under the best possible hygienic conditions, and that he should have plenty of nourishing food; when the patient is weakly, stimulants will be necessary. If required, the usual remedies for gout, rheumatism, syphilis, etc., must be employed. Iodide of potassium and mercury in small doses are administered in some cases of chronic inflammation not due to syphilis, but, as a rule, they do not then produce any marked effect.

CHAPTER II.

ACUTE SUPPURATION.

DEFINITION.—By acute suppuration is meant a process in which the inflammation, after reaching the stage of granulation, goes on to liquefaction of the tissues and the formation of pus. Pus is a fluid containing in suspension cells, chiefly leucocytes, and it may either form in the substance of the tissues, when the inflammation is deep-seated, or be given off from a free surface. We shall only consider here the question of suppuration as it occurs in the substance of the tissues; suppuration from a free surface will be discussed in connection with the treatment of wounds and ulcers.

Suppuration in the tissues occurs under two forms. In the one, the pus is contained in a well-defined cavity with a distinct wall formed of granulation tissue; in the other, it infiltrates the cellular tissue and there is no proper limiting membrane, the tissues being, so to speak, soaked with the purulent material. The former is the ordinary circumscribed acute abscess, the latter is the much more dangerous form of suppuration known as diffuse cellulitis.

CAUSES.—Acute suppuration is always due to pyogenic organisms, the circumscribed abscess being most frequently caused by the staphylococcus pyogenes aureus or albus and by other less virulent forms, especially the pneumococcus; diffuse cellulitis is usually caused by the streptococcus pyogenes. Although these organisms are the essential cause of acute suppuration, they will not necessarily cause suppuration unless they are present in large numbers or in a state of extreme virulence. In most cases other accessory factors are present which favour the growth of the organisms, as, for example, conditions enabling the organisms to rest in the part, or producing a weak spot where the tissues are less resistent than elsewhere. Thus, it is not uncommon to find acute abscesses forming in parts that have been injured, or have been the seat of inflammation, since the tissues there are in a weak state and not well calculated to resist the attack of the parasite. The organisms reach the part either directly through a wound, or indirectly through the lymphatic vessels or the blood-stream. In the case of an acute abscess the entrance is usually more or less direct. The organisms may either gain entrance to the blood through wounds, or they may pass through an unbroken surface which is no longer quite healthy; this is most prone to occur in the intestinal mucous membrane, and in acute suppurative periostitis or osteomyelitis it is not uncommon to obtain a history of diarrhœa or some other intestinal derangement immediately preceding the onset of the attack. The time taken for the formation of an acute abscess varies, and in some cases a considerable interval elapses between the onset of the inflammation and the definite formation of pus. These cases, however, should really be classed as 'sub-acute abscesses.'

Mode of Extension.—When an acute abscess has formed, its tendency is to make its way to the free surface of the skin or mucous membrane, the extension not being a mechanical process due to the pressure of the pus, but an active and vital one. This is what is known as the 'burrowing' of the abscess. When an abscess forms beneath the skin, it spreads to this structure, and ultimately bursts through it in preference to burrowing along the subcutaneous cellular tissue, because the vital changes in skin are more active than in the deeper tissues, and granulation tissue is formed there more quickly. When an abscess forms beneath a dense fascia, the conditions are different. The fascia is not converted into granulation tissue so quickly as is the areolar tissue beneath, and, consequently, an abscess so confined will, if left unopened, extend for long distances and in various directions beneath the fascia. Ultimately, however, the fascia undergoes granulation, or sloughs owing to the interference with its blood-supply by the pressure of the pus, and the latter escapes into the subcutaneous tissue. As soon as this takes place, the abscess behaves like a subcutaneous one and perforates the skin. The mode in which the abscess burrows is of great importance from the point of view of treatment. If an acute abscess be left unopened until a late period, it will be found to be no longer a single round cavity, but to contain numerous diverticula corresponding to the directions in which the inflammation has extended in the deeper tissues. Unless these diverticula be opened up thoroughly, mere evacuation of the superficial portion of the abscess often fails to arrest the suppuration. Perhaps the best example of this is seen in the breast, where the abscess rarely consists of a single round cavity, but usually possesses many diverticula, corresponding to the blood-vessels and lymphatics which accompany the ducts and lobules of the breast. Unless an abscess of this kind be opened in the manner described below, the pus in these diverticula will not be evacuated properly, and may lead to fresh extensions, the ultimate result being that the entire breast becomes riddled with sinuses.

CIRCUMSCRIBED ACUTE ABSCESS.

SYMPTOMS.—When an acute inflammation which has gone on to the formation of granulation tissue has lasted for four or five days, suppuration will almost certainly occur, and when this takes place, the centre of the brawny swelling softens, and fluctuation can be detected. When the abscess is subcutaneous, the skin ultimately gives way over the soft spot, and pus escapes. When the abscess is deep-seated, the presence of pus may not be recognised at an early period, but persistence of the acute symptoms for several days and œdema of the skin over the part are generally sufficient indications; more precise information may be obtained by a blood-count (see Appendix).

TREATMENT.—**Local.**—When pus has formed, it should be evacuated as soon as possible. If the abscess remain unopened, it will spread and cause unnecessary destruction of tissue, besides in some cases imperilling the patient's life. Hence, when symptoms of acute inflammation have lasted for several days, and especially if there be œdema of the skin over the part, and still more if rigors have occurred, no time should be lost in making an incision to evacuate the pus.

Opening an Abscess.—All the antiseptic precautions should be adopted that are practised in the treatment of wounds (see Chap. V.). This may seem an unnecessary precaution, because these abscesses, being due to pyogenic cocci, already contain the causes of suppuration. In practice, however, it is found most important to treat the abscess strictly antiseptically from the first. As a matter of fact, when an abscess is opened antiseptically it is comparatively easy to keep it aseptic, and no further suppuration occurs. On removing the first dressings, a small quantity of pus will no doubt be seen, but this is only the residual pus present in the abscess when it was opened, and if the cavity be squeezed, all that is expelled is a small quantity of clear serum; this rapidly diminishes, and in a few days the abscess cavity closes. On the other hand, when the abscess is not treated antiseptically from the first, suppuration persists. If, for example, a poultice be applied, it will be found that pus can be squeezed out, or will even flow out spontaneously whenever the poultice is removed; this is evidently due to fresh infection of the cavity, for, when asepsis is maintained, the organisms which originally caused the abscess die out.

It is of great importance to prevent infection of the surgeon's hands, so as to avoid carrying pyogenic cocci to another case. Hence, rubber gloves should always be worn, and they must be kept on not only during the actual operation, but until the dressing has been applied and all blood and pus cleared away. Unless this be done, the surgeon's hands may become infected with pus from a soiled towel or some other article.

The incision into an acute abscess should be made at the most dependent spot, if this be possible, and, when the appearance of the subsequent scar is of importance, in the lines of cleavage of the skin. Thus, abscesses in the neck should be opened by oblique rather than by longitudinal incisions (see Fig. 34). When the size of the scar is not a matter of importance, the skin incision should be long enough to allow the surgeon to introduce his finger and explore all the recesses of the abscess cavity and break down any septa that may be present; as a rule this cannot be done satisfactorily without the aid of touch. When the abscess is superficial and the size of the scar a matter of importance, it is allowable to make an incision only just large enough to admit a pair of dressing forceps. The forceps are introduced into the interior of the abscess cavity and pushed in all directions and the blades frequently expanded, so that any septa present may be broken down and the cavity thoroughly opened; a small drainage tube is then inserted. In situations, such as the anterior triangle of the neck, where the use of the knife in the deeper tissues would endanger important structures, some surgeons prefer to open the abscess by what is known as *Hilton's method*. In this plan the knife is laid aside as soon as the skin has been incised, and the deeper tissues are carefully bored through with a pair of fine dressing or sinus forceps until the pus is reached. When the forceps have entered the abscess cavity, the blades are expanded until a sufficient opening has been torn in the tissues to enable a drainage tube to be introduced. Before they are removed, the forceps should be pushed into the abscess cavity in all directions and the blades frequently expanded so as to break down any septa present. When an abscess has been opened in this way, a probe should be passed along the forceps before they are withdrawn, so as to act as a guide for the introduction of the drainage tube. Unless this be done, the opening in the fascia through which the forceps entered may be missed, for it is not always in a direct line with the opening in the skin. The simplest way of introducing the drainage tube is to thread it over the probe; the lower end of the tube is grasped with the sinus forceps and pushed into the abscess cavity, and the probe is then withdrawn whilst the forceps hold the tube in position.

Drainage.—After the abscess cavity has been opened freely, and all diverticula present have been opened up, the pus should be squeezed out gently, violence being avoided lest the granulation tissue should be injured. An indiarubber drainage tube, which should always be as large as can be introduced conveniently, should then be inserted so that its end projects into the abscess cavity; this end of the tube should be perforated with a number of large openings through which the discharge can escape. When the abscess cavity is very small, and does not extend to any depth, it may not be possible to introduce a drainage tube of sufficient size to be of use; and in that case a narrow strip of gauze, dipped in a 1 in 2000 sublimate solution, may be laid between the lips of the incision throughout its entire length; this suffices to keep the wound open sufficiently for drainage, and may be discontinued in a few days.

When the abscess is very large, and particularly when the pus has burrowed for a considerable distance, it is often necessary to provide a second, or counter-opening, to ensure efficient drainage; this is more especially necessary when the original opening has not been made at the most dependent point of the abscess cavity. In order to make a counter-opening, a pair of long dressing forceps are inserted into the cavity with the blades closed, passed down to the most dependent point, and then thrust forcibly through the soft parts so that they project beneath the skin. An incision is then made through the skin to expose the points, and the blades are separated and made to grasp a drainage tube, which is pulled through the aperture. The outer end of the tube should be cut off flush with the skin, and stitched to it. This is the simplest plan for securing a drainage tube, and the most certain to keep it in its place if the patient is under an anæsthetic; if not, it suffices to transfix the end of the drainage tube with a sterilised safety-pin. When the tube is to be stitched to the skin it is well not to push it quite down to the bottom of the cavity because the swelling subsides rapidly, and in twenty-four hours a tube which at first hardly reached the bottom of the cavity may be pushed up considerably, pulling the skin with it. It is sufficient if the tube enters the abscess cavity or any recess that requires drainage. Gauze wicks, which are often recommended, are not nearly so efficient as drainage tubes in the case of abscesses, and, if continued for any length of time, prevent the healing of the wound.

The practice, so common nowadays, of tightly packing the opening into an acute abscess should be carefully avoided. It is by no means uncommon for a strip of gauze to be packed tightly into the opening of an abscess cavity, the surgeon being under the impression that it is acting as a capillary drain. Removal of this strip of gauze is followed by a gush of pus which has been dammed up behind it; and it is evident that such a method of treatment has not only not assisted recovery but has actually retarded it; in such cases the insertion of a drainage tube is usually followed rapidly by beneficial results. When the abscess cavity has contracted down to a sinus, healing is often delayed by the assiduous care with which a long strip of gauze is thrust down to its bottom; this acts as a seton, keeping up inflammation and suppuration, and its mere removal will often be followed by rapid healing of the sinus.

The plan of washing out acute abscesses after they have been opened is not to be recommended; it can do no good whatever in the way of disinfecting the abscess, whilst it is very apt to injure the granulation wall, and thus produce a weak spot in which the organisms, which would otherwise die out, can spread. Similarly, any curetting of the cavity is to be strongly deprecated. When, however, the discharge is very foul, irrigation (as recommended below) may be very useful.

After-treatment.—In considering the after-treatment, it may be pointed out that in practice we have to deal with two types of acute abscess :—

i. Abscesses of which the type is the ordinary subcutaneous abscess due to the various forms of staphylococci, in which there are no sloughs and in which good drainage can be obtained.

ii. Abscesses in which portions of dead tissue (sloughs, necrosed bone, etc.) are present, those due to other than the ordinary pyogenic organisms, or those in which drainage is imperfect, *e.g.*, appendicitic abscesses.

The subsequent progress of these cases, and to some extent their after-treatment, differs considerably. As Lord Lister pointed out long ago, if an abscess of the first type be thoroughly opened, a drainage tube of sufficient size inserted, precautions taken not to let in fresh organisms, and the wound not irritated by injections, suppuration ceases at once ; a serous discharge takes place for a few days and the wound heals rapidly. In these cases the dressings, as a rule, should be changed on the following day, when it will be found that the swelling has diminished considerably. The drainage tube should not be removed, for if this were done it might be difficult to replace it; but if it is being pushed forward the retaining stitches should be cut and the projecting portion of tube removed. A fresh dressing is then applied, the orifice of the wound and the skin around being previously washed with a 1 in 2000 sublimate solution. The question as to when the dressing should be changed again will be determined by the amount of discharge. When the abscess was originally small, the second dressing can usually be left on for three or four days ; when, however, it was large, and there is much serous oozing, it is well to change the dressing on the following day. In most cases the drainage tube can be left out on the fourth or fifth day; the chief factor which determines this point is the amount of serous discharge present. When there is only a slight discharge there need be no hesitation in leaving out the tube ; but if it be still considerable, or purulent, a tube long enough to extend from the orifice in the skin to the entrance of the abscess cavity should be retained, as otherwise the skin wound may close with great rapidity, and the fluid will then be retained in the interior, and lead to reproduction of the abscess.

In the second type of case in which the sepsis is more acute, and especially in those in which organisms such as the bacillus coli are present, the discharge remains purulent and may be so foul and toxic that further measures are necessary. Whenever it is feasible, a free dependent opening should be made in these cases, but in some, especially in the abdomen, this may not be possible. Under such circumstances it may be advisable to syringe out the cavity once or twice daily. Care must be taken to provide a free exit for the irrigating fluid so as to avoid any risk of rupturing the abscess wall. The ordinary antiseptic solutions are of no use and may do harm, so that it is probably better to use sterile salt solution. When the discharge is foul, however, a solution of peroxide of hydrogen (10 vols.[1]) may be employed with benefit. This is a powerful oxidising agent and has also the useful property of breaking up fragments of blood-clot and soft sloughs and bringing them away.

In some cases the wound can be cleaned out effectively by sucking up the discharge through a piece of indiarubber tubing connected to a syringe. This is specially valuable in some abdominal abscesses whose walls are made up of adherent coils of bowel and in which rupture of the abscess wall and dissemination of the pus might follow irrigation.

General.—The general treatment of acute abscess is similar to that of acute inflammation (see p. 14). As soon as convalescence begins, nourishing diet, fresh air, and stimulants are necessary.

DIFFUSE CELLULITIS

In diffuse cellulitis the pus is not contained in a well-defined abscess cavity, but infiltrates the tissues. This condition is generally due to the presence of the streptococcus pyogenes.

SYMPTOMS.—The tissues are infiltrated with pus, and portions of them often die and come away afterwards as sloughs. The **local** inflammatory condition spreads rapidly, and the skin becomes red and brawny. As suppuration occurs, the swelling becomes boggy, but it is difficult to make out distinct fluctuation—at any rate, in the earlier stages; later on, however, it is not uncommon to find a distinct small fluctuating cavity in the infiltrated area. The infection spreads along the lymphatic vessels, so that red lines are seen extending up the limb to the nearest lymphatic glands quite early in the case. As the infective material spreads along the lymphatic vessels it not infrequently bursts through their walls at various points, leading to fresh patches of diffuse cellulitis. It is not uncommon for the condition to terminate in pyæmia.

The **general** symptoms accompanying this local condition are very grave, presenting the characters of asthenic inflammatory fever (see p. 3).

TREATMENT.—**Local.**—The local treatment must be prompt and radical, and must aim at giving free and early exit to the pus and sloughs. A small incision can do no good, because the pus is infiltrating the tissues, and could not escape through a small opening. It is essential that the **incision** should be free, and should extend right through the whole of the inflamed area. If one incision does not suffice to lay the whole of it open, additional ones must be made till the entire area has been incised. In any case these incisions should expose the deep fascia and must go even deeper if necessary; they should be made parallel to one another and to the great vessels of the part.

After the incisions have been made, the part should be squeezed

[1] *i.e.* one volume of the solution will yield ten volumes of oxygen.

gently, and any recesses from which pus wells out should be thoroughly opened up. After this has been done, very satisfactory results are often obtained from sponging the surface of the wound with *undiluted carbolic acid* with the view of destroying the micro-organisms if possible. The incisions should be packed for a day or two with strips of cyanide gauze wrung out of 1 in 2000 sublimate solution and sprinkled with iodoform, and outside them an ordinary antiseptic dressing should be applied (see p. 150).

After-treatment.—If this treatment fails to bring the process to a standstill, resort should be had to constant irrigation or to a water-bath,

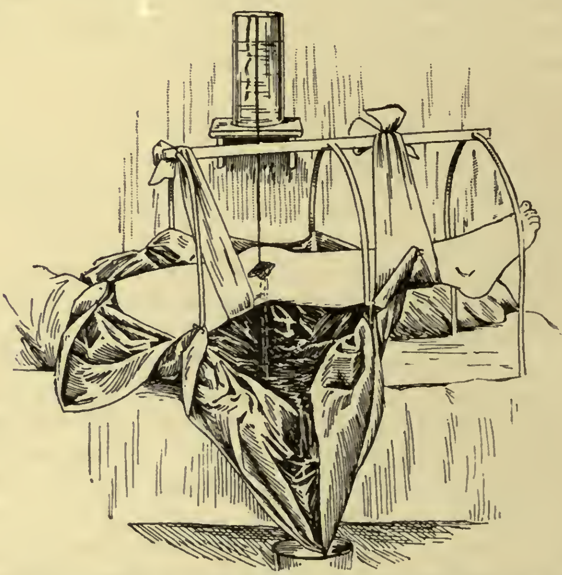


FIG. 9.—CONSTANT IRRIGATION BY MEANS OF A STRAND OF WORSTED. The method of arranging the mackintosh so as to drain off the fluid is also shown.

fresh incisions being made from time to time in any area showing signs of extension of the inflammation. In practising *irrigation* the apparatus used to convey the fluid, must not allow the latter to drop on to the wound, as this will cause intolerable pain in a very short time. If a tube be employed, its end must lie upon the skin at the highest point of the wound. Perhaps the best plan is to convey the fluid to the wound by means of capillary action. A vessel containing the lotion is placed at a higher level than the part, and a strand of worsted or gauze is placed so that one end is in the lotion, while the other lies on the upper part of the wound; the fluid runs along these threads very quickly, and the wound is thus constantly washed with it (see Fig. 9). The liquid used for irrigation should be at or slightly above the temperature of the body (*i.e.* 100°–105° F.), and this can be arranged for by keeping a night-light under the vessel containing it.

It is well to add some antiseptic to the irrigating fluid, but it is important to avoid those which precipitate albumen ; otherwise the surface of the wound becomes coated with a layer of coagulated albumen, and the pus and organisms will accumulate beneath it instead of being washed away. Perhaps the best for the purpose are sanitas (a teaspoonful to the tumbler of water), iodine water (a teaspoonful of the

FIG. 10.—CONSTANT IRRIGATION. The method of forming a drain for the surplus fluid by means of the mackintosh is also shown. The nozzle of the irrigator should always lie in direct contact with the edge of the sore.

tincture of iodine to a pint of water) or permanganate of potash (two to four grains to the ounce). Care must be taken not to wet the bed, and a mackintosh should be so arranged that the fluid is conducted into a basin at the bedside (see Fig. 10). If possible, it is well to have the limb suspended over an empty vessel, but in any case a piece of mackintosh should be arranged beneath it. The limb should be raised to a higher level than the rest of the body. If the arm be affected, it may rest upon a pillow covered with a mackintosh, the upper end of which is tucked around the shoulders of the patient, and the sides so folded that a drain is formed that will conduct the fluid away to a suitable vessel at the bedside. A necessary precaution in employing irrigation is to prevent the neighbourhood of the affected part becoming sodden with water, and in order to avoid this, the skin around should be smeared with sterilised grease or oil.

Irrigation should be continued until the inflammation has ceased to be acute, when some simple dressing should take its place; otherwise the granulations are likely to become œdematous, and a weak or œdematous ulcer is formed which will not heal properly. An excellent dressing at this stage is eucalyptus or weak boric ointment (half the strength of the pharmacopœial ointment) spread on butter-cloth, with a layer of boric lint applied outside. The protective and boric lint dressing described in the treatment of ulcers is also good (see p. 51).

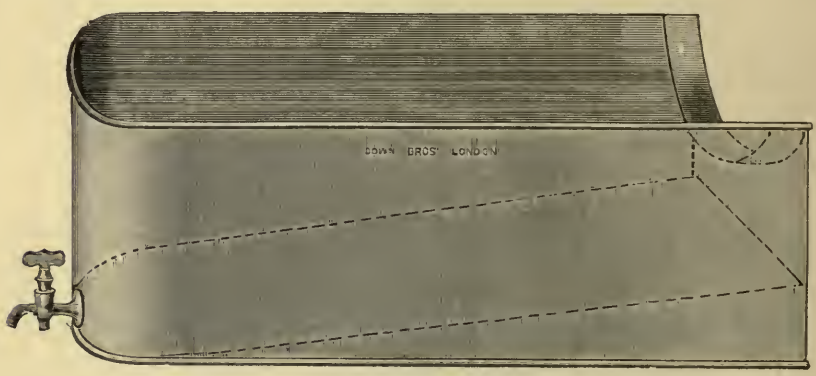


FIG. 11.—WATER-BATH FOR LEG. The sloping floor of the bath is meant for the leg to rest upon: it is better, however, to have holes bored through the sides of the bath near the top, to which can be fastened slings of muslin in which the limb rests. The bath, when in use, is covered over with a thick blanket to maintain its temperature.

Another good method of treatment is the *water-bath*, although it is hardly so satisfactory as irrigation. In irrigation, the secretions being washed away as rapidly as they form, no nidus remains in which micro-organisms can grow; in the water-bath, the discharges are not washed away so rapidly, but they are diluted, and at the same time the bath supplies warmth and moisture. If an antiseptic, such as sanitas, permanganate of potash, boric acid, or weak iodine, be added to the fluid, the growth of the organisms is inhibited to some extent.

The limb is suspended, by means of a large gauze or muslin sling, in a covered bath (see Fig. 11), filled with water at a temperature of about 100° F. containing in solution one of the antiseptics mentioned above. The bath should be furnished with a tap at its lowest point, and a gentle stream of water should flow through it by means of a syphon apparatus from a reservoir above the level of the limb; the water in this reservoir should be kept at 110° F. as a good deal of heat is lost as the fluid runs through the tube. The skin around the wound should be rubbed with sterilised oil. The water-bath should only be used during the day; during the night boric lint, wetted with hot boric lotion and covered with mackintosh, should be applied to form a fomentation. The bath requires constant attention in order to keep the water warm, to prevent it from overflowing, and to empty it from time to time, and, therefore, the patient would be unable to get proper sleep if the bath were employed during the night; moreover, prolonged soaking in warm water does not improve the resisting power of the tissues. When the feet or the forearm are affected, a water-bath answers very well, but, in the latter case, the patient must be propped up nearly into the sitting posture.

When the upper part of the limb or the trunk is affected, the patient must lie in an ordinary bath arranged for the purpose. Unless the trunk be entirely submerged, special precautions must be taken, by fastening a blanket round the neck and covering in the bath, to prevent the patient taking cold.

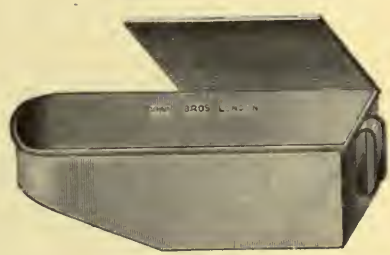


Fig. 12.—Water-bath for the Hand and Forearm. The apparatus works more satisfactorily if it be furnished with a tap, as in Fig. 11.

Care must also be taken to prevent the water in the bath becoming foul, and this necessitates repeated changing of its contents. In the case of a bath in which the whole patient is immersed, the water should be changed completely three or four times a day, or more often if there is much foul matter discharged into it. When a limb-bath is used, the fluid must be changed every twelve hours and the bath scrubbed out. Another point of extreme importance, especially in hospital practice, is the necessity for thorough disinfection of the bath after use. The cases for which this method of treatment is employed are often the subjects of an infection with organisms of great virulence, some of which are possessed of great resisting powers. The best method of disinfection is to immerse the bath in a large vessel, such as a copper and boil it; if this be impossible, the bath should be filled nearly full of water, covered over, and supported over a gas-ring or powerful spirit-stove, so that the water and steam within it may thoroughly disinfect it. A mere superficial scrubbing with carbolic acid—the method that is most commonly employed—cannot be regarded with entire satisfaction. If sterilisation by boiling be inconvenient, the bath may be filled with a strong carbolic solution and allowed to stand for twenty-four hours. All baths should be of plain metal and not painted, varnished, or japanned.

Moist dressings are often useful, but they are inferior to the use of irrigation or the warm bath. They consist of boric lint wrung out of warm boric lotion or weak sublimate solution, and applied over the whole surface of the wound, and then covered with a piece of mackintosh extending beyond the lint in all directions. This requires to be changed at least three or four times a day, when the wound and the skin around should be washed with a 1 in 2000 perchloride solution.

When the acute symptoms have passed off, and the wounds have become reduced to simple healing sinuses, an antiseptic dressing of cyanide gauze and wool is perhaps the best, and should be employed until the sinuses have contracted down and there are only flat granulating sores left. When the wounds are quite superficial, there is no objection to the employment of eucalyptus ointment, under which they will heal

FIG. 13.—METHOD OF APPLYING A SPLINT TO THE HAND AND FOREARM IN CELLULITIS. To show the position that the thumb should be made to assume.

rapidly. The ointment should be spread thickly on pieces of boric lint, and at each dressing all the ointment from the previous application should be removed, together with any scabs and crusts of discharge. Ointment should not be used as a dressing over the mouth of a deep sinus.

Certain other points in the local treatment of diffuse cellulitis must be attended to. It is of primary importance that the part should be placed absolutely at *rest*, if necessary on a splint, and the *position* of the limb should be so arranged that, should stiffness result, as it is apt to do, the limb will be in the position most convenient for the patient. For example, in the case of the hand, the fingers should not be extended, because if they become stiff in that position they are useless; they should be about half-bent over a pad, and the thumb especially should be kept apart from the fingers, and allowed to drop. If the thumb be kept at the same level as the fingers, and stiffness result, the power of opposition is more or less lost; whereas, if it be allowed to drop below the level of the fingers, fairly small objects can be picked up between the fingers and thumb, even with comparatively limited movement. To lay the whole hand flat on a splint, with the thumb at the side of the fingers, is a mistake so commonly made that too much attention cannot be called to it. The elbow or the foot should be put up at a right angle, the knee very slightly flexed.

Movement.—When the acute inflammation has passed off, steps must be taken to prevent stiffness supervening, for in diffuse cellulitis, spreading as it does in the planes of the cellular tissue, and accompanied, as it often is, by sloughing, the tissues are apt to become adherent to one another. Thus, in the forearm, owing to the inflammation causing adhesion of the muscles to one another, and owing to gangrene of portions of the muscle or even of the tendons, the hand may become permanently useless. Hence, the splint must be given up directly the acute symptoms have passed off, and, to a certain extent, rapidity of healing must be sacrificed to the attempt to promote movement. In the first instance *passive movements* only are attempted, and these are combined with the use of *massage* (see p. 23).

Active movements should also be employed, preferably against some form of resistance. A convenient method of accomplishing this in the case of the forearm and hand is to make a ball of Berlin wool about the size of a small orange and to instruct the patient to grasp this and compress it slowly and regularly a number of times at intervals during the day. The ball of wool affords a comparatively firm but elastic article to grasp; its size and tension can be regulated at will. The patient should be encouraged to move the finger, wrist, and elbow joints, two or three times daily; in addition, massage and passive movement of these joints ought also to be practised at least once daily on the lines laid down on p. 23.

In bad cases, passive movement under an anæsthetic may be required two or three times a week, but care must be taken not to do too much at a time, as otherwise fresh effusion may be caused, and the object of the procedure defeated.

General.—Diffuse cellulitis is a very grave disease, and the patient is apt to pass into the typhoid state, hence free stimulation is necessary. Perhaps the best stimulant is brandy, but when the patient is very exhausted, champagne may have a better effect—at any rate, temporarily. As much as six ounces of brandy or double that quantity of champagne may be administered in the twenty-four hours, and when the pulse is very weak, an even larger amount may be necessary. Strychnine injected hypodermically is also of great value. Ten-grain doses of quinine may be given every four hours till marked symptoms of cinchonism are produced. Easily digested, concentrated, nourishing fluid food should be given in quantities as large as the patient can tolerate.

Anti-streptococcic serum has been used frequently of recent years for this affection. Up to the present, however, it has not been uniformly successful. Information concerning this remedy will be found on p. 163. Vaccine treatment may also be employed (see Appendix).

The essential facts to remember with regard to diffuse cellulitis in general are the rapidity of the disease, the necessity for very early surgical intervention, and the desirability of extremely thorough measures. As a matter of fact, one is much more likely to do too little than too much in the way of free incisions.

Diffuse cellulitis in certain special situations, *e.g.* scalp, neck, etc., will be treated of in their appropriate places.

CHAPTER III.

ULCERATION.

DEFINITION.—An ulcer has been roughly defined as any breach of the skin or mucous membrane which does not tend to heal. This definition, however, includes, not merely ulcers proper, the result of inflammatory processes, but also ulcerating tumours, with which we shall not deal in the present chapter. True ulceration is an inflammatory process, and a more accurate definition is, that an ulcer is a progressive loss of substance in skin or mucous membrane which has been the seat of inflammatory changes that have gone on to granulation. This continued loss of substance is not due to death of visible portions of tissue (in which case there would be gangrene), but to degeneration of cells, or death of microscopic portions of the tissue—what is known as molecular death.

CLASSIFICATION.—There are two great classes of ulcers proper, namely: (1) those which are not due to any specific virus, but are caused by various local troubles, such as imperfections in the blood-supply or the innervation of the part—this class may be spoken of as the chronic non-infective ulcer; and (2) those in which a specific virus is at the root of the ulcerative process; this class includes a large group of ulcers, by far the greater number being the result of syphilitic or tuberculous disease, and is known as the chronic infective ulcer. In them there is, preceding the ulcerative process, a formation of new tissue which has a special tendency to undergo degeneration; for example, syphilitic nodules undergo gummatous degeneration, and tubercles undergo caseation: one result of these changes when affecting the skin is ulceration. These chronic infective ulcers will be discussed in detail in connection with syphilis, tubercle, etc.; we shall only deal here with the chronic non-infective ulcers which result directly from inflammation.

CAUSES.—Before proceeding to discuss the treatment of ulcers, it is necessary to consider the causes which lead to the ulcerative process, and the various types of ulcers they produce. The causes of ulceration are mainly local, and among the chief is anything which tends to produce *defective circulation of blood* in the part. For example, if an inflamed limb hangs down, the return of the venous blood is impeded ; consequently, less arterial blood flows to the part, and its nutrition is therefore interfered with ; this is the explanation of the fact that the great majority of the non-infective ulcers affect the lower extremities. In addition to impeding the circulation of the blood, the dependent position of the leg acts also by producing a condition of lymph-stasis. Were the arterial and venous channels composed of a rigid and unyielding material, the dynamics of the circulation would be unaffected by posture, but this is far from being the case. The vessels of the inflamed part are already leaky, and as the increased pressure in the arterioles due to the weight of the column of blood in the arteries raises the capillary pressure upon the arterial side, and as the corresponding column of blood in the veins increases the intra-capillary pressure upon the venous side, an increased exudation of lymph occurs through the endothelial walls. The lymphatics, like the other vessels, are acting at a mechanical disadvantage and hence the dependent limb becomes swollen, and the vitality of its tissues is markedly lessened, since they are supplied with stagnant lymph.

A granulating wound on the leg is very apt to become the subject of an ulcerative process if the patient continue to stand about much, or to walk on the leg, or even to hang it down. Perhaps one of the most frequent causes of ulceration is the presence of varicose veins, especially when the veins affected are the small tributaries in the skin. This condition presents a very marked obstacle to the venous return ; consequently there is stagnation of blood and the nutrition of the part is impaired. Again, ulceration may result from imperfect blood-supply apart from any venous obstruction, as is seen in the cases in which there is atheroma of the arteries, and if the dependent position be habitually assumed in the presence of this disease, the ulcerative process may go on rapidly. This imperfect blood-supply may also be brought about by the pressure of the inflammatory exudation in the tissues around the ulcer interfering mechanically with the circulation of blood in the part. This is frequently the case when the sore is situated over loose connective tissue, the meshes of which become distended with lymph and which is, moreover, sparsely supplied with blood-vessels.

In addition to these causes depending upon defective circulation of blood, ulceration is greatly favoured by *a feeble condition of the tissues*, such as occurs in old age. A wound on the leg in a young person, even though he be the subject of varicose veins and still continue to walk about, is not nearly so likely to lead to an ulcer as is a similar injury in an old person ; to a great extent this is due to the greater vitality and recuperative power of the tissues in the young. At the same time, in old persons there is generally a diminution in the arterial supply, and thus there is a combination of at least two of the causes of ulceration. A similar result is brought about by anything which temporarily enfeebles the vitality of the part, such as severe and long-continued exposure to cold; when not severe enough to produce gangrene, this may lead to rapid ulceration.

A very frequent cause of ulceration is *difficulty in the contraction of the sore.* When a wound heals by granulation, an important element in the healing process is the diminution in the size of the sore from the contraction of the newly formed fibrous tissue; when this contraction cannot occur, a time will come when healing will cease and ulceration will take place, especially if the sore be large. The constant unsuccessful efforts of the new fibrous tissue to contract seem to irritate the part and arrest the healing. This inability to contract may result from the great size of the sore, from its adhesion to tissues, such as a bone or a dense fascia, which do not permit of contraction, or from induration of the margin of the sore, as in a callous ulcer. Not only does the difficulty in contraction lead to ulceration *per se*, but the new tissue, in contracting, compresses the blood-vessels going to the part, and so diminishes the blood-supply.

Again, *irritation of a sore* may lead to ulceration instead of healing, either mechanically, as by pressure, by friction of the dressings, etc., or chemically, as by irritation due either to the lotions used in the treatment, (for example, carbolic acid), or to decomposing secretions. When the discharge from a sore decomposes, irritating substances are formed and may lead to extensive ulceration, especially if they do not escape readily. This is most often the case when the discharge dries up and forms crusts; under these crusts this decomposing, irritating secretion accumulates, and ulceration occurs instead of healing. Hence in treating an ulcer or a septic granulating wound it is of great importance not to permit the formation of crusts or scabs.

Another local cause which leads to ulceration is *movement.* When a sore is situated over a muscle, or over a fascia which is in frequent movement, especially if it be adherent to either, ulceration is more likely to occur than in one situated elsewhere.

Ulceration may also be set up by accidental *contamination of the wound.* A wound which is healing will begin to ulcerate if virulent pyogenic organisms attack it; they lead to the formation of an inflammatory ulcer. Among other specific infections of sores may be mentioned diphtheria and phagedena, the latter of which will be dealt with more fully in connection with gangrene.

Ulcers also occur in parts where *the nervous supply is imperfect*—for example, after paralysis or neuritis. Several factors may come into play in these cases. In the first place, if a limb be insensitive to pain, exposure to pressure is not noticed or is tolerated, and severe ulcers may be produced before the patient is aware that anything is wrong. In these cases the ulcer heals readily under appropriate treatment. On the other hand, in lesions of the spinal cord, as in infantile paralysis, or in lesions of the posterior nerve roots and ganglia, such as locomotor ataxy, the ulcers which form are often very resistant to treatment, although there may be no anæsthesia. It is to this group that the term *trophic ulcer* should be applied. In many cases there are anæsthesia and loss of trophic influence.

Lastly, ulcers may occur in connection with certain *constitutional conditions*, such as diabetes, scurvy, etc. Diabetes leads to ulceration, partly from the diminished blood-supply due to the endarteritis which so often accompanies it, and partly from the increased susceptibility of the tissues to septic infection. Scurvy leads to extravasation of blood into the tissues which interferes with their vitality, and often ends in sloughing of the skin.

FIG. 14.—THE APPEARANCES PRESENTED BY A HEALING ULCER. (*a*) Granulating surface; (*b*) pink zone of epithelium; (*c*) bluish zone of thicker epithelium; (*d*) whitish zone of desquamating epithelium.

Signs of Healing.—It is important to recognise when a sore is healing and when it is not. When a portion of tissue, including an area of skin, has been removed and a wound has been left, the edges of which cannot be approximated, it will be found after a few days that the wound has commenced to heal by granulation. If the process of repair be not hindered either by the occurrence of sepsis or by mechanical irritation, the granulations fill the cavity of the wound rapidly, so that a flat slightly depressed surface is formed, covered with bright-red nodules about the size of a millet-seed. These do not bleed when they are lightly touched, but ooze freely if they are roughly handled. From this granulating surface comes a small amount of serous discharge, which, on microscopical examination may be found to contain a few leucocytes, but the fluid does not merit the name of pus. At the edges of the wound the epithelium is found spreading inwards; at the innermost part, where there is a single layer of epithelial cells covering in the granulations, the presence of the epithelium is indicated merely by a flat pink zone; beyond this, where the epithelium is thicker, there is a distinct bluish line, and outside this again, a zone in which the superficial epithelial cells have already begun to desquamate and, becoming sodden with the dressings and discharge from the wound, form a white line around it. It is the presence of the red line that indicates that healing is actually taking place. This point can best be made out by drying the surface of the ulcer, when it will be found that the bare granulating surface becomes moist again at once, while the red line around remains dry.

VARIETIES.—Various forms of ulcers are described, of which the following may be mentioned :—

Simple Ulcer.—This may be described as a granulating wound which is kept from healing by various local causes, such as pressure, or friction from the dressings, muscular movements, scratching, interference with the vascular supply, chemical agencies, and so forth. In the early stage, the simple ulcer forms a flat sore covered with granulations of a yellow or brownish-red colour, on a level with the surrounding skin or only slightly depressed below it ; its margins are sharply cut and the surrounding parts are slightly œdematous. These ulcers extend fairly rapidly when no proper care is taken. In certain cases, these and other ulcers may become the seat of acute inflammation, and then we have the second form, namely, the inflamed ulcer.

Inflamed Ulcer.—This is an ulcer which has become the seat of acute inflammation, as the result of some mechanical or chemical irritation, of bad methods of treatment, or, usually, of septic infection. The surface of the ulcer is intensely red and angry-looking, it bleeds readily, secretes a large quantity of pus, extends with great rapidity and is not infrequently covered with small shreds of gangrenous tissue ; the skin around is bright red and œdematous, the borders are irregular and eaten away, and it is not uncommon for fresh ulcers to develop rapidly around the margin of the original sore. These fresh ulcers at first are separated from one another and from the original sore by bridges of skin, which are sometimes quite narrow, intensely inflamed, swollen, and apt to slough.

Irritable Ulcer.—This form of ulcer is sometimes met with in neurotic women as a small sore with a somewhat elevated surface, and intensely tender to the slightest touch. It commonly occurs about the external malleolus, and may be associated with menstrual disorders. A similar ulcer may be met with in men, but very rarely.

Weak Ulcer.—A simple ulcer is apt to become a weak one either from too small a quantity of blood reaching the part, or from deficient quality of the blood, as for example when ulcerations occur during the progress of some constitutional disease. There are various kinds of weak ulcers, depending upon the cause producing them. In one form, the granulations become smooth and somewhat yellowish, the secretions thin, small in amount and very apt to form a scab, and the edges pale and flat. In a second form, the granulations become œdematous, and this usually happens in connection with some general cause of œdema, or some local interference with the circulation, especially the venous return. In a third form, the granulations show excessive growth ; this generally occurs when the ulceration is due, either to the inability of the sore to contract, or to irritation from the materials used for dressing. In such cases the granulations become prominent, vascular, soft, and bleed readily, and the condition is popularly known as 'proud flesh.'

Diphtheritic and Phagedenic Ulcer.—Any ulcer may be attacked by some specific virus, such as that of diphtheria or that which produces phagedena. In the latter case its surface becomes covered with a greyish, pulpy material which rapidly infiltrates the surrounding skin and cellular tissue, extends both superficially and deeply, leads to extensive and very rapid destruction and constitutional infection, and not uncommonly ends in the death of the patient.

Varicose Ulcer.—This is a type of ulcer which originates in connection with varicose veins, especially when the smaller veins of the skin are affected. This condition leads to imperfect nutrition of the skin, and to the occurrence of either a local dermatitis ('varicose eczema') or a periphlebitis ending in the formation of a small abscess around the vein ; the abscess bursts, and gives rise to an ulcer. In the case of the eczematous ulcer, the patient usually scratches the irritable part and produces a wound which becomes inflamed and rapidly develops into an ulcer. However produced, these varicose ulcers are usually small and superficial at first, with œdema around and with soft, prominent, and somewhat œdematous granulations. They are often situated immediately over one of the enlarged veins, and the ulcerative process occasionally extends through the wall of the vessel itself. In this way a severe hæmorrhage may occur. If the patient continues to walk about, the condition gradually passes into that of—

Callous Ulcer.—As a result of the continued interference with the venous return, local œdema takes place ; there is exudation of coagulable lymph in the interstices of the cellular tissue, and cells accumulate there. The result is that the arterioles are pressed upon, and the nutrition of the sore is interfered with. The exuded material coagulates, and becomes organised to a considerable extent and hence the skin and subcutaneous tissues around the ulcer become thickened, so that finally the surface of the ulcer is on a considerably lower plane than its edge; this is not really due to extension of the ulcer in depth, but to the elevation of the surrounding parts owing to the great thickening Thus, the characteristics of a callous ulcer are: a sore at a deeper level than the surrounding skin, an indurated condition of the base and of the surrounding parts, and a surface of a pale yellow colour devoid of granulation, and secreting a small quantity of thin fluid. These ulcers are found almost exclusively among the labouring class, who are unable to obtain the rest necessary for their cure.

Hæmorrhagic Ulcer.—This form of ulcer occurs especially in patients suffering from scurvy ; the surface of the sore is red, swollen, and bleeds readily, and the blood sometimes coagulates on the surface, forming a firm clot which has been likened to 'bullock's liver.'

Pressure Ulcer.—This form of ulcer occurs in the sole of the foot, and is the result of long-continued but not necessarily severe pressure. The pressure leads to thickening of the epidermis and the formation of a callosity, underneath which inflammation and suppuration occur. When the thickened epidermis is removed, a deep sore is exposed, with great hypertrophy of the skin around the edge.

The Paralytic Ulcer occurs in connection with deficient innervation especially in infantile paralysis and after injuries to nerves. In paralysed limbs it is not uncommon to meet with atonic ulcers which are painless, quite superficial and often multiple. As a rule they have imperfect granulations upon the surface, and most commonly occur about the phalanges of the fingers and toes. They are also found on the sole of the foot, however, and in this situation they are generally ascribed to pressure, and tend to assume the appearances characteristic of pressure ulcers.

In connection with these ulcers due to pressure upon a paralysed part, the so-called *perforating ulcer of the foot* deserves special notice. It occurs on parts exposed to marked pressure, and is chiefly met with beneath the heads of the metatarsal bones, more especially that of the great toe. It is generally seen in men over forty who have much standing or walking, and it is not necessarily connected directly with any actual paralytic condition of the limb, but is supposed to result from a condition of peripheral neuritis. It is also found in locomotor ataxia and diabetes. The affection commences as a callosity, followed by inflammation of the skin underneath, and a sore forms, resembling at first an ordinary pressure ulcer in all respects. The ulcer extends in depth, without any great superficial increase in size, becomes more or less funnel-shaped, and rapidly penetrates as far as the bone. The latter may then become the seat of a rarefying osteitis, and may be entirely destroyed opposite the ulcer, which continues to increase in depth, until ultimately the dorsum of the foot is reached and a complete perforation is established. When the ball of the toe is the seat of the affection, the metatarso-phalangeal joint is often opened and destroyed. The base of the ulcer is generally covered with reddish warty granulations, the skin is foul, and the cavity of the ulcer is filled up with a dense mass of epidermis, which undergoes decomposition. In some cases the epidermis spreads down the sides of the ulcer, and in many there is marked proliferation of it around the margins of the sore.

In certain **constitutional states**, such as diabetes, ulcers may form. In diabetes, inflammation or ulceration may follow the slightest scratch or cut, and the chief characteristics of a diabetic ulcer are its rapid spread, the presence of considerable inflammation around it, and often sloughing of the tissues. The endarteritis which occurs in diabetes and the special liability of the tissues in that affection to septic infection, have probably much to do with the rapidity of spread and the inflammatory condition of diabetic ulcers.

DANGERS OF ULCERS.—The rapid and permanent cure of an ulcer is a matter of great importance; not only is a patient afflicted with an ulcer more or less incapacitated from work, but he is liable to various accidents which may permanently cripple him or even lead to his death. For example, when an ulcer is situated over a muscular part, the muscles may become so matted together that the movements of the limb are much interfered with. This is more especially the case if the ulcer lies over tendons; the tendon and tendon-sheath may then become adherent to one another and to the surrounding parts.

Perhaps the most common disabilities resulting from ulcers are those due to the contraction occurring during the efforts at healing. When an ulcer is situated over a joint, for example, the healing process may lead to so much contraction as to fix the joint permanently in a faulty (usually a flexed) position. Again, when an ulcer surrounds the leg completely, the contraction may be enough to constrict the vessels coming from the parts below, and so cause great and permanent œdema and often complete uselessness of the foot. A further risk of an ulcer is that the veins in its vicinity may become inflamed, and an extensive simple or septic phlebitis may follow. A patient with an open ulcer is subject to all the ordinary septic diseases, more especially erysipelas. Lastly, it may be pointed out that epithelioma not infrequently develops upon an ulcer of long standing.

TREATMENT.—Various principles must be attended to in order to promote the healing process. In the first place, it is essential for rapid healing that the level of the sore should be nearly, if not quite, the same as that of the surrounding parts; secondly, its margins should be moveable, in order to permit of contraction; and thirdly, the granulations on the surface should be healthy. There are, therefore, three practical points to attend to in the treatment of ulcers: (1) To remove any cause that is keeping up the ulceration, the most important of which have already been mentioned; (2) to improve the condition of the surface and margins of the ulcer; (3) to promote healing in every possible way, and to provide for the formation of as sound a scar as can be obtained.

Removal of the Cause.—The first essential in the treatment of all ulcers, is to seek out the cause and remove it; the causes have been indicated fully in the preceding paragraphs, and nothing further need be said about them here.

Rest.—In all cases rest is highly desirable. The patient must be prohibited from walking, and, if necessary, the movements of the neighbouring joints must be prevented by the application of suitable splints. If splints be employed, they should be so arranged that the limb will be in the position most serviceable to the patient if there be any subsequent stiffness either of joints or muscles. For example, in the case of the leg, on which ulcers are most frequently met with, it is well to apply a splint which reaches above the knee, and fixes the foot at right angles to the leg.

Promoting the Venous Return.—The danger of venous obstruction has already been insisted upon ; it may lead to the transformation of a simple or varicose ulcer into a callous one, and the ulcer will refuse to heal as long as no provision is made for the proper return of blood from the affected area. This indication may be met in various ways, but the most efficient is to place the part on a higher level than the heart. Patients who are suffering from ulcers of the leg should be put to bed with the limb elevated on a pillow, and the knee and ankle-joints fixed, and should not be allowed to get up for any purpose whatever until cicatrisation is complete. Any relaxation of this rule will not only delay the healing of the ulcer, but may lead to an extension of the ulceration. When the part is elevated, the venous return is greatly favoured, and the exudation which has been poured out is rapidly absorbed even without any other treatment. As a result, the pressure upon the arterioles going to the surface of the ulcer is removed, and a plentiful flow of arterial blood is again supplied to it. Thus rest and the elevated position not only favour the return of blood from the part, but also the flow of blood to it.

Promoting Absorption of the Exudation.—Measures should also be taken to get rid of the exudation, which presses on and interferes with the circulation in the part. The elevated position and rest in bed are no doubt sufficient to do this of themselves ; but if time be an object, various measures may be taken to accelerate the absorption of the exudation. Of these, one of the best is *massage*. When massage is employed with a view of getting rid of the thickening around an ulcer, it should be applied first to the parts above the ulcer ; as the skin gets softer in that region, the area subjected to the massage may be increased downwards. If the massage were applied first to the part below the ulcer, the absorption would not be satisfactory, owing to the presence of the exudation above.

Another way in which the exudation may be got rid of is by *pressure*, and this is especially useful when patients will not lie up. Pressure may be applied in two ways ; either by strapping, or by elastic bandages. The older plan was to use *strapping*, but this is not so good as elastic pressure. If strapping be used, strips of adhesive plaster are applied fairly tightly around the ulcer and the parts in its vicinity. These strips should be rather more than an inch broad and rather longer than the circumference of the limb. They are applied from below upwards, the centre of each strip being applied at a point opposite the centre of the ulcer, so that as the two ends are brought together over the limb they pull the edges of the ulcer together (see Fig. 15). If the strips were applied with their centres over the ulcer, the reverse would be the case ; when they were pulled tight the edges of the ulcer would be separated. The strips should overlap each other for about two-thirds of their breadth, so that only about a third of each is exposed. In this way the whole region of the ulcer, as well as the thickened tissues above and below, are firmly supported and pressed upon by a series of strips of adhesive plaster applied from below upwards. Before applying the strapping, the whole limb should be shaved, as otherwise great annoyance is caused to the patient when it is peeled off.

One great objection to strapping is that the discharge from the ulcer is confined beneath it, and there undergoes decomposition, and consequently fresh ulceration occurs. The ulcer, therefore, should be

FIG. 15.—METHOD OF STRAPPING AN ULCER. A dressing has been applied over the ulcer, which is represented by a dotted outline.

disinfected before the strapping is applied, and boric lint should be placed over its surface so as to absorb and prevent the decomposition of fluids. Unless this be done, it will be necessary to cut away the lower parts of the strapping so as to allow the discharge to escape, a procedure which necessarily weakens it. The strapping should be renewed every second day unless there is much discharge, when it must be renewed daily.

Strapping has now been largely abandoned in favour of the *elastic bandage*, that known as Martin's being the most suitable form. Martin's bandage is a thin sheet of pure rubber, cut into strips about three inches wide and of varying lengths ; this is wound around the limb, commencing at the ball of the toes and extending up as far as the knee. The best form is that containing a number of perforations to permit of evaporation ; otherwise the perspiration accumulates beneath the bandage and may set up a dermatitis.

The above methods of applying pressure are only continued, in the case of patients who can afford the time to lie up, until the exudation has become absorbed. If continued longer, they interfere with the nutrition of the limb.

Another method of getting rid of the exudation accompanying a callous ulcer is the application of *blisters*. When a blister is applied to the skin, more blood is sent to the part and the lymph flow is increased; if a blister be applied around a callous ulcer (the limb meanwhile being kept at rest in the elevated position), it is remarkable how quickly the callous condition disappears, and the edges become soft and in a condition favourable for healing.

The essential point in employing a blister in the treatment of an ulcer is that it should not be applied directly over the raw surface, otherwise the cantharides is apt to be absorbed, and may lead to serious irritation of the kidneys. This must be borne in mind in cases of callous ulcer especially, for many of the patients suffering from this affection are the subjects of Bright's disease. Hence, the blister should be raised round the margin of the ulcer only; the surface of the ulcer should not be allowed to come into contact with the cantharides. For the method of application of blisters, see p. 19. Usually one blister will suffice, and it will be found that, by the time the blistered surface has healed, the callous condition of the ulcer has disappeared, and its edges are in a satisfactory condition.

Avoidance of Irritation—Another important point in the treatment of all ulcers is to get rid of anything that irritates the surface of the sore. The irritation may be mechanical, such as that caused by dressings applied directly to the surface of the sore, or chemical, such as unsuitable lotions or decomposing discharges; the chemical causes are the more common. In order to avoid *mechanical irritation*, the dressing, whether it be gauze or boric lint, should not be applied directly to the surface of the sore, but oiled silk protective or an antiseptic ointment should be interposed.

A most important point is the avoidance of *chemical irritation* either from lotions or decomposing discharges. The lotions used should be antiseptic, but irritating antiseptics, such as strong carbolic acid, should not be selected.

Disinfection of the Ulcer.—The presence of decomposing discharge on the surface of an ulcer interferes materially with the healing process, and it is therefore most important to remedy, as far as possible, the septic condition of the sore at the commencement of the treatment. In order to do this, we recommend the following method of procedure. In the first place, the skin should be disinfected for a considerable area around the ulcer. Disinfecting the surface of the ulcer alone and leaving the skin septic simply means that the surface will again become infected in a few days. Therefore the skin should be thoroughly washed with ether soap and a disinfecting lotion, and shaved. The best lotion to use for the purpose is a 1 in 20 watery solution of carbolic acid in which is dissolved one five-hundredth part of corrosive sublimate; this will be referred to hereafter as 'strong mixture.' The lotion can be conveniently prepared by adding to a pint of 1 in 20 carbolic acid two soloids of perchloride of mercury of the usual strength (8·75 gr.). It should be noted that 'strong mixture' cannot be made by mixing equal parts of 1 in 20 carbolic and 1 in 500 perchloride of mercury lotions.

The part is first thoroughly washed with soap and this mixture, and then well scrubbed with a nail-brush dipped in the mixture; finally, the strong mixture may be removed from the skin by washing it with a 1 in 2000 watery solution of corrosive sublimate. It is not always easy to disinfect the surface of an ulcer completely at one sitting; the most rapidly efficacious plan seems to be to swab it thoroughly over with *undiluted carbolic acid*. A small piece of sponge is dipped in liquefied carbolic acid, rubbed firmly over the whole surface of the granulations and sides of the ulcer and allowed to act for some minutes. This no doubt destroys the granulations, but they are usually unhealthy, and of no use in healing; the method is a very effectual one. The application causes a good deal of pain at the time, but this soon passes off, for the acid is a local anæsthetic. When the granulations are prominent, or soft and œdematous, it is well to scrape them away with a sharp spoon; if the ulcer be large a general anæsthetic is necessary.

Other methods of purifying the ulcer have been employed. Lord Lister used to apply a solution of *chloride of zinc* (40 gr. to the ounce of water). This however is much more painful than the application of the undiluted carbolic acid, the pain lasting for hours, while the method does not seem to be so efficient.

When it does not seem desirable to employ undiluted carbolic acid, disinfection of the sore may be obtained by packing the surface with lint dipped in 1 to 5 *carbolic oil*; if this be changed twice a day, the foul condition will usually be got rid of in the course of two or three days. The oil should be applied to the surface of the ulcer alone; if applied to the skin it may produce much irritation.

First Dressing after Disinfection.—The best dressing to employ after the disinfection is cyanide gauze and salicylic wool, as used in the treatment of wounds (see Chap. V.). The gauze should be soaked in 1 in 4000 sublimate solution and applied directly to the surface of the ulcer, and the salicylic wool[1] is put on outside the gauze. When there is any doubt as to the completeness of the disinfection, it is well to pack the recesses of the ulcer with small pieces of cyanide gauze lightly squeezed out of 1 in 2000 sublimate solution.

[1] Although these medicated wools may be applied outside the gauze dressings just as they are taken from the packages in which they are sold, it is an undoubted advantage to subject them to the action of superheated steam if possible (see p. 97).

Boric Lint and Protective Dressing.—After two or three days, when it is clear that asepsis has been obtained, and the tissues are getting into a more healthy condition, the use of gauze should be given up, and unirritating dressings and lotions employed. A saturated watery solution of boric acid is an excellent lotion, while the protective and boric lint dressing introduced by Lord Lister is as good a dressing as can be employed. In this method the surface of the ulcer is washed with boric lotion, and a piece of protective (oiled silk covered with a layer of dextrin) is soaked in carbolic lotion (1 in 20), and then dipped in boric lotion to wash away the acid, and applied over the wound. The protective should overlap the sore in all directions, but ought not to extend too far beyond its edge, as otherwise sepsis may spread in beneath it. Outside the protective, pieces of boric lint, wrung out of boric lotion, are wrapped around the limb, overlapping the protective to a considerable extent in all directions. This dressing should be changed daily for the first few days; and every second or third day the skin around should be washed with carbolic lotion (1 in 20), which must not be allowed to run on to the sore. The limb should be shaved at least once a week. If there be much discharge, holes should be cut in the centre of the protective so as to allow it to drain into the lint.

Wet Boric Dressing.—When the ulcer is painful, or when there are sloughs on its surface, wet boric lint should be applied without any protective, the lint being used in the same way as a water dressing. The boric lint is soaked in hot boric lotion and applied over the ulcer so as to extend well beyond it, and outside this, overlapping it in all directions, is fastened mackintosh, oiled silk, or guttapercha tissue, previously disinfected by boiling, or by immersion in carbolic lotion. This wet boric dressing, fomentation or poultice, as it is sometimes called, should be changed twice a day, but should not be continued after the irritable condition of the sore has ceased, or after the sloughs have separated. If it be continued too long, the granulations become œdematous and a form of weak ulcer is established.

Boric Ointment.—Antiseptic ointments are especially useful when the ulcers are healing rapidly; zinc ointment, which is commonly employed, is very objectionable on account of its septicity. The most generally useful ointment is either unguentum acidi borici or unguentum eucalypti. The boric ointment of the Pharmacopœia, however, will be found to be too strong to permit rapid healing, and, in most cases, one of half its strength is the most suitable. This should be spread thinly and evenly on muslin or butter-cloth, no portion of the surface being left uncovered by the ointment; a piece of boric lint is applied outside and the whole is secured by a bandage.

Cases are sometimes met with in which the surface of the sore is very delicate and seems to resent the presence of any application, however unirritating it may be; as long as anything is in contact with it, cicatrisation will not take place. Under these circumstances, the best plan is to dispense with dressings entirely and merely to place over the ulcer some contrivance that will prevent anything coming into contact with its surface. This may be accomplished by fixing over it a perforated *celluloid shield* (see Fig. 16) of suitable size and shape, or a wire cage moulded to fit the limb, leaving the granulating surface bare. The shield should be removed two or three times daily, and the raw surface washed with boric lotion to remove any discharge. The limb should be fixed in the elevated position, and the surrounding skin should be disinfected previously as recommended above. If a wire cage be used, the limb should be slung in a cradle and the cage surrounded by a dressing. If there be much tendency to the formation of crusts from the drying of the discharge, a moist dressing may be applied outside the shield to

Fig. 16.—Celluloid Wound-shields. The shield is inserted in the centre of a sheet of adhesive plaster, by means of which it is applied to the limb. In the figures, two holes are represented in each shield; these are to permit of evaporation. If it be desired to keep the surface of the ulcer quite moist, non-perforated shields may be used.

prevent evaporation. A piece of gauze, soaked in boric lotion and covered with mackintosh, will suffice. In some cases Bier's treatment is of value; this method has already been described on p. 13.

Skin-grafting to obtain a Sound Scar.—A very important object in the treatment of all ulcers is to obtain a sound scar. In the ulcers affecting the lower extremity in elderly people, the scar resulting from spontaneous healing is weak, and readily breaks down if the patient does much standing or walking. The patient is therefore frequently obliged to give up work in order to get the ulcer re-healed, or must be content to employ means which merely prevent the extension of the ulcer, and give relief from some of the discomfort. When the best possible scar is desired, and when it is important to avoid great contraction, it is necessary to adopt some method of skin-grafting. There are three plans by which rapid healing of a sore may be brought about: Reverdin's epidermis grafting, Thiersch's skin-grafting, and the use of the whole thickness of the skin; of these the best in our opinion is that employed by Thiersch.

In **Reverdin's method** small thin portions of the superficial layer of the skin are snipped off with curved scissors. Pieces about the size of a hemp-seed are planted on the surface of the granulations at short distances from each other; epidermic growth occurs from each of these little points, and the result is that numerous small islands of epithelium form over the surface of the sore. If the grafts be close enough together and the conditions be favourable to healing, these islands soon coalesce, and thus rapid cicatrisation is obtained. These grafts should not be too far apart, because they appear to have only a limited power of reproduction. Each graft usually gives rise to an island of epidermis about the size of a sixpence, and then growth seems to come to a standstill. The result of this method of epidermic grafting is that rapid healing is obtained in many cases, especially in burns and sores on the trunk, where the skin is freely movable over the deeper parts. The contraction of the subsequent cicatrix is considerably diminished thereby, because less granulation tissue is formed than if the sore had to heal altogether from the margin, for the amount of contraction depends entirely on the amount of young granulation tissue produced. Nevertheless, considerable contraction will inevitably occur where healing has been obtained in this way, and the resulting scar is not materially stronger than that obtained by permitting the sore to heal from the edge.

With a view of obtaining a sounder scar, thicker and more extensive portions of the skin must be taken, and the grafts must be applied close together. There are two ways of doing this: either by using the whole thickness of the skin, or by employing Thiersch's method, in which about half the thickness of the skin is shaved off. We need not describe the procedure where the whole thickness of the skin is employed, partly because the results are not satisfactory, and partly because all the conditions for which it was introduced are better fulfilled by Thiersch's method. Skin-grafts can be taken either from the patient himself or from a second individual. When the patient is very debilitated, the cutaneous epithelium shares in the general malnutrition, and under these circumstances a graft from a healthy subject might succeed better than one taken from the patient.

Thiersch's Method.—In employing Thiersch's method, the skin which is to be used for the grafting must first be shaved and disinfected in the usual manner (see p. 50). The presence of hairs on the grafts seems to interfere materially with their union.

Preparation of the Ulcer.—(*a*) *Preliminary.*—It is of no use to graft a sore which is actually ulcerating; it must be brought into a healthy condition, and healing must have commenced before grafting is likely to be successful. The best criterion that healing is taking place is the presence, at the edges, of the dry red line which indicates recently formed epithelium. Some surgeons wait for a considerably longer time before grafting, in order to get a firm layer of granulations; but our experience is that the sore may be safely grafted upon as soon as healing begins around the edge. A second essential is that the sore shall be clean. If the discharges be septic, the graft—which is after all merely a piece of dying tissue—will become impregnated with decomposing pus, and may rapidly become loosened, die, and undergo decomposition. The methods of rendering the ulcer aseptic have already been described (see p. 49).

(*b*) *Operative.*—The following is the method of procedure. The patient is put under an anæsthetic, and the granulations over the whole surface of the ulcer are forcibly scrubbed off with a firm nail-brush or are evenly scraped away, taking care, however, only to remove the soft layer of granulations and not to go through the deeper one of newly formed fibrous tissue into the fat. A surface is thus left which is smooth, highly vascular, and firm, and consists of the deeper layers of granulation tissue which have already become organised into fibrous tissue. In the case of ulcers on the lower extremity, it is also advisable to remove those portions of the edge which have already become covered with new epithelium. If the grafting be limited to the parts actually unhealed, the result is disappointing, as a rule; for, while the part grafted remains sound, the margin where spontaneous healing had occurred is apt to break down, and thus a narrow line of ulceration appears at the site of the edge of the ulcer.

After the layer of granulations has been removed and the newly healed edge of the ulcer has been cut away, the bleeding must be arrested completely before the grafts are applied. The most rapid method is to pour a few drops of adrenalin chloride (1 in 1000) solution over the raw surface, when the oozing ceases immediately. If adrenalin be not at hand the following plan will be found satisfactory. Any spouting vessel is clamped, and a large piece of sterilised protective (see p. 51) or thin sheet-rubber is applied over the raw surface. Outside this several sponges are placed, and a sterilised bandage is bound firmly over them; if the sore be small and an assistant be available, he may apply the pressure. Pressure is employed indirectly through the protective in this way, because if it were made directly upon the surface of the wound by means of sponges, bleeding would recommence when the latter were removed, as they stick to the raw surface.

Cutting the Grafts.—While the bleeding is being arrested, the surgeon cuts his skin-grafts from any part of the body that he thinks fit; as a rule they are taken from the front of the thigh, but the side of the abdomen may be made use of when the grafts are to be applied to the face. The area from which the grafts are to be cut is disinfected (see p. 49) and the surgeon grasps the limb from behind with his left hand in such a way as to make the skin over the front of the limb as tense as possible; in doing this he pushes the soft parts well forward so as to make the anterior aspect of the limb as flat as possible. The skin is further put on the stretch vertically by an assistant who pulls it upwards and downwards (see Fig. 17). These precautions are important, as, without them, it is almost impossible to cut a graft of even width. The razor (see Fig. 18), which should have a very broad blade, is dipped in boric lotion and is kept constantly wet by this solution whilst the grafts are being cut, just as in making microscopical sections of fresh tissues. Unless this be done, the graft adheres to the blade and may be either partially or wholly cut through before a sufficient length has been obtained. The razor is made to penetrate through about half the thick-

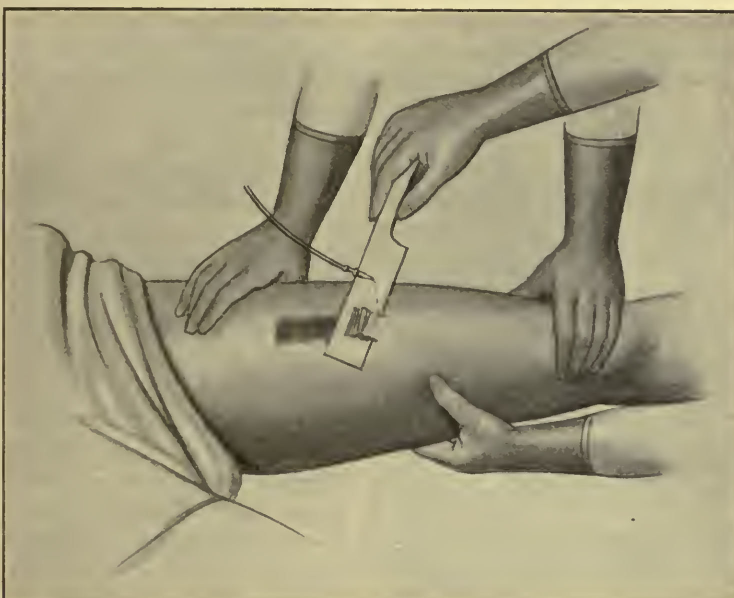


Fig. 17.—Thiersch's Method of Skin-grafting. *Cutting the grafts.* The figure is intended to show how the parts are steadied while the grafts are being cut.

Fig. 18.—Thiersch's Razor for Skin-grafting. The instrument is wholly metal and can be got with a blade of any width. The wider the blade the better can long, wide grafts be cut.

ness of the skin, and then, by a lateral sawing motion, the grafts are cut as broad and as long as possible. After a little practice it is easy to cut grafts about two inches in breadth, and four or five in length. If one graft be insufficient, it is best to slide it off the razor and leave it lying on the bleeding surface; in this way it is kept warm and moist. Some surgeons put the graft into warm sterilised saline solution, and it is then said to spread out more easily afterwards. Small skin-grafts can be cut under local anæsthesia. For this purpose a 1 to 4 per cent. solution of β-eucaine in normal saline solution containing 1 part in 10,000 of adrenalin is employed. For details of the method of producing local anæsthesia see Appendix.

Application of Grafts.—When a sufficient number of grafts has been cut, the bandage, sponges, and protective are removed from the raw surface of the ulcer and the grafts are applied to it if the bleeding has stopped, as is generally the case. The raw surface usually has a thin layer of blood-clot upon it, and this should be wiped away. Each graft is lifted with forceps or the fingers, and applied with the cut surface downwards, and then the graft is carefully unfolded by means of two probes and stretched evenly over the surface (see Fig. 19). The grafts should overlap the edges of the skin and also each other, so that no part of the raw surface is left exposed, for granulations always spring up on the uncovered parts, and are apt to destroy the grafts in their vicinity; moreover, a thin scar is left at these points which may break down subsequently. The graft is always thinner at its edge than at its centre, and it is these thin edges which overlap each other or the edge of the skin; there is no real sloughing of these overlapping edges.

Fig. 19.—Thiersch's Method of Skin-grafting. *The graft applied.* The skin-grafts overlap the margins of the ulcer and one another.

Dressing the Grafts. — Air-bubbles and blood-clot collect beneath the grafts during their application, and must be got rid of by pressure so applied as not to detach the grafts; unless this be done, the grafts may fail to adhere. The following is a good plan: strips of sterilised protective (see p. 51) about an inch broad and long enough to overlap the wound are applied to the grafted surface from below upwards, each strip overlapping the one below, and extending well on to the skin at each end (see Fig. 20). If each strip be grasped by its two ends and pressed down firmly on the limb as it is put on, the pressure suffices to expel the air-bubbles and blood, and also to arrest further capillary oozing. Another plan, which is even more efficacious after a little practice, is to lay a fine soft flat sponge over the grafts and then press it down firmly, taking care to avoid any lateral movement which would dislodge the grafts. When the sponge is lifted the grafts will be found to adhere firmly.

Various dressings may be used. When protective has been applied as described above, cyanide gauze wrung out of 1 in 4000 sublimate solution is applied, with salicylic wool outside it. When the grafts have been made to adhere by sponge pressure, a very useful dressing is plain gauze sterilised by boiling and then smeared with vaseline sterilised by heat. The limb should be placed upon a splint, or so fixed that movement cannot occur.

Some surgeons prefer perforated silver foil to the protective. There is no need to cut this in strips as the perforations allow discharges to escape; it has also the advantage of being readily sterilised by boiling, but is not quite so pliable as the protective is. Thin sheet-rubber, which can be perforated with holes if desired, is also used. An excellent protective tissue, apparently composed of cellulose, has been introduced recently. This has the advantage that it can be boiled without deterioration, and, as it is transparent, the grafts can be inspected without disturbance.

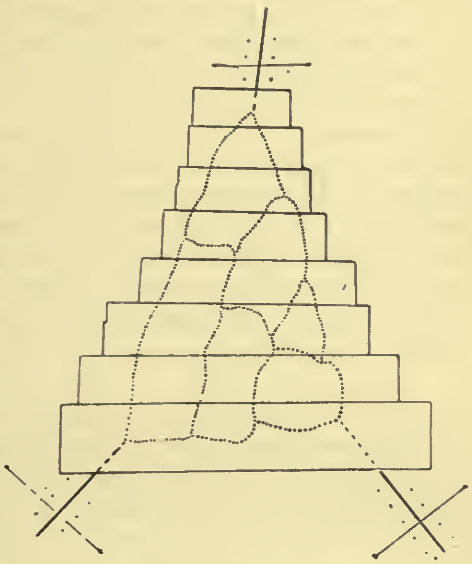


FIG. 20.—THIERSCH'S METHOD OF SKIN-GRAFTING. *Applying the protective.* The grafts (indicated by the dotted line) are covered with overlapping strips of protective tissue.

The place from which the grafts have been taken may be dressed with dilute boric ointment, which need not be disturbed for ten days. At the end of that time the whole surface will usually be healed, unless the razor has somewhere gone deeper than is necessary. If healing be not quite complete, the boric ointment may be re-applied.

Changing the First Dressing.—The dressing should be left on the grafted surface for about five days; in some cases it may even be left for a week. If the wound be aseptic, no suppuration or decomposition takes place beneath it. Before being removed, the dressing should be thoroughly soaked with a 1 in 2000 sublimate solution, for the protective or the dressing may stick at the edge and adhere to a graft, which may thus be peeled off unless great care be taken. The parts should be gently cleansed with the same solution, and a dressing similar to that put on originally should be employed for about another week. At the end of that time the grafts are fairly firmly adherent, and then the half-strength boric ointment is the best application.

After-treatment.—It will be found that, even at the first dressing, the grafts present a pink colour and are adherent to the deeper surface, though they are still readily detachable. In the course of about a week the old cuticle peels off, but no raw surface is left. Later on, there is a great tendency to the formation of new epithelium, cornification, and drying-up, and it is in avoiding the latter condition that ointments are so useful. In fact, till the scar is absolutely sound, it is well to keep the surface covered with some greasy application, the best being the half-strength boric ointment. For many months the grafted surface is likely to scale or crack and this might prove a starting-point for the occurrence of sepsis which would cause the newly grafted area to slough. It is important to keep the scar as supple as possible, and therefore it should be constantly anointed with cold-cream, vaseline, or lanoline. Grafted surfaces upon the face, however, do not betray this tendency for any length of time.

Time required for Cure.—It is important to know when the patient may be allowed to walk about after an ulcer of the leg has been skin-grafted. If he begins too soon, the grafts will almost certainly become detached. That this will be so, is evident from a consideration of the mode by which the adhesion of the grafts takes place. At first they adhere to the surface of the sore simply by means of the effused and coagulated lymph. Cells rapidly spread into this lymph, and in the course of two or three days, the space between the graft and the raw surface is occupied by a mass of young cells. In this tissue young blood-vessels develop and penetrate into the grafts, whilst, at the same time, the cells of the grafts grow and assist in the development of the young tissue and of the blood-vessels. Thus the graft becomes vascularised; but for a considerable time the tissue between it and the surface of the sore contains many young blood-vessels with delicate walls, and therefore, if the patient stands erect and allows the pressure of the column of blood to tell on these vessels, they rupture, and bleeding occurs beneath the graft and leads to its detachment. It requires a long time before the graft is firmly incorporated with the tissue beneath by the development of elastic fibres; indeed, it may be reckoned that this union is not complete until from three to six months have elapsed. The graft will in all probability be destroyed if the patient walks about within three months of the grafting. Hence, unless that time can be devoted to the treatment, it is not worth while employing skin-grafting for ulcers of the lower limbs. By this, however, it is not implied that it is necessary to keep the patient in bed for the whole time, but merely that the foot must not be allowed to hang down, nor must any weight be borne upon it. At the end of about six weeks the patient may be allowed to get up and lie on a sofa or sit with the leg on another chair, but the limb must not be permitted to hang down. At the end of about three months he may be allowed to get about, but in order to prevent the detachment of the grafts, he should be fitted with a knee-rest and peg on which he walks, the leg projecting out behind him. If possible he should not put his foot to the ground until six months have elapsed.

In cases of sores on other parts of the body, where the erect posture does not cause congestion of the part, the patient may be allowed to walk about after the first three weeks.

Results.—The scar which results after skin-grafting performed in this manner is of a satisfactory character, and ulcers which have been intractable for years may be closed satisfactorily by its means. In order to obtain anything in the nature of a permanent cure, however, the prescribed period of rest must be adhered to rigidly.

Treatment when a Patient cannot lie up.—The surgeon has also to treat ulcers in the out-patient department of hospitals, where the measures above referred to cannot be employed, as the patient is unable to afford the necessary time, and the question then arises, What is best to be done ? In the first place, one cannot expect to cure the ulcer, though in some rare cases the ulcer does actually heal ; in the majority, however, it remains open, even though it may be somewhat improved. Nevertheless, a good deal may be done to alleviate the patient's troubles and prevent the further spread of the sore. In treating out-patients it is impossible to get rid of the dependent position of the limb and the bad results this produces, but these may be mitigated by giving as much support to the circulation as possible ; the septic condition of the wound may also be got rid of.

These, then, are the two points to be aimed at in the 'ambulatory' treatment of ulcers of the leg—support of the circulation and asepsis of the sore. The asepsis of the sore is effected by the means already described (see p. 49). The most popular method of supporting the circulation is by the use of Martin's rubber bandage (see p. 48) ; it should be applied in the morning before the patient gets out of bed, and should be put on loosely, being simply rolled spirally around the limb. The rubber should not be stretched when applied, for one cannot gauge the amount of pressure exerted, and as the limb swells when the patient commences to walk about, the bandage may become unbearably tight. If put on loosely, the œdema which occurs on walking, distends the bandage and puts it on the stretch, and in the course of an hour or two it provides a fairly satisfactory amount of support. When the patient goes to bed, the bandage should be removed, washed, and hung up to dry ; it is a mistake to wear it during the night. When first introduced, the rubber bandage was applied direct to the surface of the sore without any dressing, but, if this be done, the discharge decomposes beneath the bandage and prevents healing. Hence the ulcer should be disinfected and then a suitable dressing—to be mentioned immediately—should be applied beneath the bandage. The dressing must not be of a greasy nature as otherwise the rubber will be spoilt.

We consider, however, that the method known as *Unna's bandage* is superior to Martin's and we advise its adoption in the first instance at any rate. This is a bandage stiffened with gelatine, and its advantages are that the patient cannot meddle with the sore, and that it gives a uniform elastic support without unnecessary pressure. It can be applied in various ways, but the method we prefer is as follows. In the first place, the sore and the skin around are thoroughly disinfected, and a dressing of protective and boric lint is applied; later on, half-strength boric, or eucalyptus or any other suitable antiseptic ointment may be substituted. After the sore has been properly purified, a mixture consisting of 40 parts of water, 40 of glycerine and 10 of gelatine, with some oxide of zinc to make it stiffer, is applied to the outside of the dressing. This mixture becomes solid at the ordinary temperature, but is readily liquefied by gentle heat.[1] The liquefied material is painted over the outside of the dressing, and a double-headed bandage is put on, beginning over the centre of the ulcer, one roll going downwards towards the toes and the other upwards towards the knee. This bandage is applied smoothly and not tightly, the melted mixture is then painted on it, and, before it sets, another bandage dipped in hot water is applied over it. This dries in a very short time and forms a firm, elastic, and at the same time not too heavy support to the limb, and thus some of the disadvantages of other dressings, more especially the irregularity of the pressure which often occurs in a Martin's bandage, are avoided. If possible, Unna's bandage should be put on early in the day before the leg has swollen from walking about. The dressing should be changed according to the amount of discharge present; usually at first every other day, but at less frequent intervals as the discharge diminishes. It is readily removed by putting the leg in a tub of warm water so as to melt the gelatine; the bandages can then be unwound easily. When the ulcer has healed, the parts should be supported for some time by Unna's bandage; massage should also be used, more especially if the scar be hard and fixed and the muscles atrophied. The legs should be frequently immersed in a warm bath, and lanoline should be rubbed into the skin to soften the epidermis.

SPECIAL POINTS IN THE TREATMENT OF THE VARIOUS FORMS OF ULCER.

The foregoing remarks as to treatment apply to all ulcers, but it will now be well to mention certain points peculiar to the treatment of the individual forms.

[1] This is best done in a large glue-pot, or a gallipot stood in a saucepan of boiling water; in the latter case a piece of wood should be placed beneath the gallipot in order to prevent it from cracking. A very useful formula when there is any dermatitis is: Gelatine 30 parts, oxide of zinc 30 parts, glycerine 50 parts, water 90 parts. Melt, and add ichthyol 6 parts.

Simple Ulcer.—The simple ulcer is one that is prevented from healing by various local causes not usually of a serious character. The chief of these are standing and walking, especially if varicose veins be present or the patient be advanced in years. If these causes be removed, and the limb be placed at rest in a suitable position, the sore will heal rapidly. In the treatment of a simple ulcer, then, the patient should be put to bed, the leg elevated on a pillow, fixed if necessary, and suitable dressings applied to the part. It is well to disinfect the surface of the ulcer (see p. 49), but when the surface is comparatively healthy it is hardly necessary to destroy the granulations with pure carbolic acid; washing them with 1 in 2000 sublimate solution will suffice. The best dressing is the half-strength boric ointment, used as described on p. 51, and changed either daily or every alternate day. When the ulcer is large, especially if the patient be old, skin-grafting (see p. 53) should be employed.

Inflamed Ulcer.—Here there is not only ulceration but also acute inflammation, and both conditions require treatment. The patient should be put to bed with the leg elevated, and warm antiseptic fomentations applied. The best of these is boric lint dipped in warm 1 in 4000 sublimate solution or boric lotion, applied wet over the ulcer and the skin in the vicinity, and overlapped in all directions by guttapercha tissue or mackintosh. This dressing should be changed twice a day at least, and oftener if the inflammation be severe or the pain acute. Before doing this, it is well to disinfect the surface of the sore by the application of undiluted carbolic acid. Another important point is local depletion. When these ulcers are multiple they are often separated by bridges of skin which are much swollen and inflamed and are prone to become gangrenous. Division of these bridges will often prevent the impending gangrene and the consequent loss of tissue, while at the same time it allows the escape of exudation and of blood, and so improves the inflammatory condition. Even when these bridges of skin are not present, considerable improvement will be obtained by making incisions into the inflamed tissues around, the cuts radiating from the centre of the ulcer. When the inflammation has subsided, the treatment is that of a healing sore. Skin-grafting (see p. 53) will be called for when the ulcer is large.

Weak Ulcer.—In a weak ulcer the cause of the weakness (see p. 43) must be sought for and removed if possible. If general anæmia be the cause, iron should be administered; an excellent way to give it is in the form of Blaud's capsules, commencing with doses of five grains three times a day. Some of the graver forms of anæmia, however, yield more quickly and satisfactorily to arsenic, and therefore these drugs may be given in combination, or, if the iron does not seem to suit, liquor arsenicalis should be substituted for it, beginning with doses of three minims after food twice a day, and increasing the dose by one minim every third or fourth day up to twelve minims or more. The medicinal treatment must be accompanied by nourishing diet and good hygienic conditions. When the weakness of the ulcer is due to œdema from heart or kidney disease, treatment suitable to these affections must be employed.

Among the local conditions the first that should be looked for is difficulty in the contraction of the sore. This may result from adhesion to the deeper parts, from the hardness of the tissues around the sore, as in the callous ulcer, or from the size of the original sore and the large amount of cicatricial tissue formed during healing, etc. If it be due simply to the denseness of the scar, apart from exudation into the tissues, lateral incisions through the sound parts beyond will sometimes allow the ulcer to heal. When the latter is adherent to bone it should be detached, portions of the thickened margin cut away, the surface scraped with a sharp spoon, and skin-grafting employed. In some instances portions of bone have been removed, or joints have been excised to allow of contraction taking place; but this can very rarely be necessary, especially since the introduction of Thiersch's method of skin-grafting. In every case of weak ulcer the part must be kept at rest in the elevated position, and the weak granulations should be destroyed by scraping them away and applying undiluted carbolic acid to the raw surface ; the ulcer is thus disinfected at the same time.

When the granulations become exuberant in an ulcer which has been rendered aseptic, they should be rubbed over freely with a pencil of solid nitrate of silver, the surface of the sore being dried before the caustic is applied. Should there be excessive growth of the granulations afterwards, they may be kept down by repeated applications of solid nitrate of silver or sulphate of copper made daily, or every other day. The caustic must not be applied to the healing edge.

Various stimulant applications are usually advised for weak ulcers, such as solutions of sulphate of zinc (the so-called red lotion),[1] or sulphate of copper in a strength of two grains to the ounce of water. These are chiefly of use in that form of weak ulcer in which the surface is inactive and shows few and imperfect granulations. They are useless in the cases with exuberant or œdematous granulations. It is doubtful how far benefit results from these applications, and they should only be used in the particular form of weak ulcer to which we have alluded, and which is most often associated with general anæmia. When the sore is œdematous, the best dressing is weak boric ointment ; the protective and boric lint dressing tends to foster œdema of the granulations by confining the moisture. As soon as any of these ulcers get into a healthy condition, skin-grafting should be employed.

Irritable Ulcer.—The intense pain associated with this form of ulcer is best met by cauterising the ulcer thoroughly with solid nitrate of silver, so as to destroy completely the sensitive terminations of the nerve.

[1] The formula for 'red lotion' is as follows: ℞ acidi borici, gr. x; zinci sulphatis gr. j ; spiritus rosmarini; spiritus lavandulæ co., āā ♏ix; aquam ad ℥j.

Treatment on the principles recommended for a simple ulcer should be carried out subsequently. When these ulcers are quite small, however, complete excision with immediate skin-grafting is the best treatment.

Phagedenic Ulcer.—This ulcer requires energetic treatment in order to destroy the infected tissues. In order to do this, the slough should be scraped away with a sharp spoon or clipped off with scissors, and then the actual cautery (see p. 20), potassa fusa (see p. 21), or nitric acid should be applied to the surface of the sore; of these the actual cautery is the best. It should be heated to white heat, and the parts thoroughly destroyed by it; Paquelin's cautery will also answer the purpose. It is possible to gauge the amount of destruction done by means of the cautery, whereas caustic potash generally destroys more of the tissue than is really necessary, and the action of nitric acid is interfered with by the coagulation of the albumen that it causes, so that, as a rule, it does not extend sufficiently deeply. After the application of the cautery, undiluted carbolic acid should be sponged over the surface, and a dressing of strong carbolic oil (1 to 5) should be applied (see p. 50). When nitric acid is used, its action should be neutralised, after the lapse of a few minutes, by pouring a strong solution of ordinary washing-soda on the wound; this should be done until effervescence, from the liberation of carbonic acid gas, ceases. In these ulcers the first object is not to obtain healing, but to eradicate a dangerous bacterial poison which spreads with great rapidity.

Varicose Ulcer.—This ulcer must be treated by rest in the elevated position, disinfection of the sore, the application of protective and boric lint dressing, or boric ointment, and subsequent skin-grafting. But the patient should not be allowed to go about again till the varicose veins themselves have been treated. As long as the limb is elevated, the presence of varicose veins does not delay the healing, but directly the patient begins to walk about they favour the subsequent breaking down of the ulcer in a very marked degree. As, however, under proper conditions, the varicose veins do not interfere with the healing of the wound, it is well to defer the operation until the ulcer has closed, so as to avoid any risk of sepsis in connection with the operation on the veins. The treatment of varicose veins is referred to in detail in Vol. II.

Callous Ulcer.—Here the obstacle to healing is the callous condition of the surrounding parts, and the surgeon's first efforts must be directed to getting rid of this. If the limb be put at rest, the leg elevated, and the sore rendered aseptic, this callous condition will subside comparatively quickly, and in the course of two or three weeks the sore will present a healthy appearance and the healing process will begin. When it is desirable to expedite matters, or when the thickening of the tissues does not disappear as quickly as usual, some of the other plans, which have been referred to on p. 18, may be employed; of these the best is the application of a blister, provided that the kidneys be healthy. After the callous edges of the ulcer have been got rid of, and the sore has assumed a healthy condition, skin-grafting should be employed (see p. 52); when varicose veins are present, they should be operated on after the wound has healed, but before the patient is allowed to walk about. For the 'ambulatory' treatment of callous ulcer, see p. 59.

Pressure Ulcer.—A pressure ulcer occurring in the centre of a callosity is sometimes very obstinate in healing, and the best treatment is to cut away the callosity which surrounds the ulcer, and to scrape and disinfect the surface of the latter. In this way a shallow healthy sore is left, which heals comparatively quickly if the limb be elevated and kept at rest in the usual manner. When a pressure ulcer occurs in the foot, it is perhaps well to excise and skin-graft it, in order to avoid the thin scar which results from the natural process of healing, and which is very apt to remain tender or break down subsequently; and when the patient first begins to walk about, the boot should be excavated at the part corresponding to the scar, so that pressure does not tell—for a time, at any rate—on the site of the ulcer.

Paralytic Ulcer.—It is often very difficult to obtain healing, and stimulating applications should be employed. In the early stage cyanide gauze should be applied directly to the raw surface, after the ulcer has been disinfected, and is very useful as a means of inducing granulation. After granulation has occurred, the best dressing is perhaps boric lint soaked in balsam of Peru. This dressing is antiseptic, and possesses a markedly stimulating action; it should be changed daily. When the healing is well in progress, the half-strength boric ointment (see p. 51) should be substituted. The position of the limb, rest, the administration of nourishing diet, etc., must of course be attended to. Besides this, the application of spirits of wine to the parts around, and the use of massage (see p. 23) and electricity to the whole limb, should be had recourse to, with the view of improving the nutrition and increasing the circulation. The electric current may be employed in one of two ways. The simplest plan consists in covering the whole of the ulcerated area with a layer of gauze or absorbent wool, thoroughly wetted with salt solution, and applying to this the negative pole of a galvanic battery, the positive pole being applied to the spinal column. A current of about five milliampères should be used at first; if this cause pain it must be diminished. The apparatus should be so arranged that the circuit can be opened and closed about thirty times per minute. The sittings should occupy from ten to fifteen minutes and may be made daily. The strength of the current may be cautiously increased up to ten or more milliampères, but it should never be strong enough to cause pain. The other method is to immerse the affected limb in a small electrical bath. This may be improvised by using a china basin or wooden tub or trough of suitable size, which is filled with salt solution and in which the affected part in immersed. The electrodes, which should be in the form of flat copper plates connected with the poles of a battery, are placed on either side of the limb, the negative being in direct contact with the ulcer. A current sufficiently weak for the patient to bear without discomfort must be employed. This method is more cumbrous than the other and offers no advantages over it.

Perforating ulcers of the foot are often obstinate under treatment. The limb may be placed at rest on a splint in the elevated position for a long time without the slightest attempt at healing occurring. One reason for this no doubt is the tendency of the epithelium to fill up the cavity and decompose there, or else to spread down the edges of the ulcer. The most satisfactory plan in these cases is to excise the edges and sides of the ulcer, cut away the whole of the callosity around, scrape out the bottom of the ulcer until sound tissue is reached and then disinfect the whole surface with undiluted carbolic acid (see p. 50), and dress it antiseptically.

Fig. 21.—Excision of a Perforating Ulcer of the Foot.—Dorsum of the foot showing the opening of a perforating ulcer between the first and second toes. The broken line shows the incision round the margin of the ulcer continued up into the cleft between the toes.

Healing will not begin until the cavity of the ulcer has filled up with granulations, and therefore it is well to promote granulation by stuffing the cavity lightly with cyanide gauze which greatly favours this by its irritation. The gauze should be changed daily, but the packing should be left out as soon as granulation has occurred. When the granulations have grown up nearly to the level of the surrounding surface, some non-irritating dressing, such as the half-strength boric ointment (see p. 51), may be substituted for it. When the ulcer is extensive, skin-grafting may be employed with advantage.

When the ulcer is situated between the great and the next toe it can often be excised conveniently. An incision is made around the opening of the ulcer extending forward into the cleft between the toes (see Fig. 21). A similar incision is then made upon the plantar surface of the foot extending forwards to meet the first incision between the toes. As the incisions are deepened the space between the first and second metatarsals becomes opened up, a free exposure of the walls of the perforating ulcer can be made and any sloughs or dead bone removed. After the operation the parts fall into position and the wound generally heals well by granulation.

Diabetic Ulcer.—In these cases the local treatment must be carried out on the same principles—namely, disinfection, position, and careful dressing. Of dressings, boric fomentations are the best at first; but these ulcers will not do well unless something be done to improve the constitutional condition. In the case of diabetes, the patient must be put upon an anti-diabetic diet and codeine (see p. 80). Operations are not satisfactory in a diabetic patient, and this is the one form of ulcer in which skin-grafting cannot be recommended. If the ulcer be extensive and tend to become gangrenous, the case should be treated as one of diabetic gangrene. In less severe cases the ulcer should be allowed to heal if it will, and Unna's bandage should be employed afterwards, with the object of preventing a recurrence.

CHAPTER IV.

GANGRENE.

DEFINITION.—By gangrene is meant death of macroscopic portions of the tissues, and the term is usually employed only when the portion which dies is extensive, more especially when the whole or part of an extremity is affected. If the portion of gangrenous tissue be small, the dead part is termed a slough, and the process is spoken of as sloughing.

CLASSIFICATION.—In speaking of gangrene two classifications are employed—the one a clinical classification into dry and moist gangrene, the other an etiological one into direct, indirect, and specific gangrene. The use of the latter classification makes the whole subject of treatment more intelligible.

SYMPTOMS.—It will save repetition if we speak first of the terms dry and moist gangrene. **Dry Gangrene** is the form in which the gangrene occurs so slowly that the fluids of the part have time to dry up. Under these circumstances the dead tissues do not form proper pabulum for the ordinary putrefactive bacteria, and therefore the usual signs of putrefaction are wanting. The part usually has a mouldy rather than a foul odour, and there is not the same amount of septic absorption as in the moist form. The patient is at first comparatively or altogether free from fever and symptoms of septic poisoning, and there is less inflammation in the neighbourhood of the dead part than is the case in the moist variety. The gangrenous part is black, shrivelled up, greasy, and semi-transparent from the breaking down of the fat, so that the tendons and bones can be seen through the skin. At the junction of the dead with the living part there is a faint red blush. In dry gangrene, as a rule, the line of demarcation is not permanent, and after a time fresh gangrene may appear above it. The chief symptom is pain.

Moist Gangrene, on the other hand, is characterised by rapid putrefaction of the dead part, and the patient soon shows signs of septic absorption. The gangrenous part is generally reddish at first, and ultimately becomes black; bullæ containing dark foul fluid form over it, and it crepitates on pressure from the presence of gas. The soft parts become liquefied and separate from the living tissues and, in the case of a limb, from the bone as a dark, slimy, foul-smelling mass. If the patient lives, there is marked redness round the edge of the gangrene and rapid formation of a line of demarcation. Moist gangrene produces much more severe disturbance to the system than does the dry form.

TREATMENT—**Local.**—To a great extent the treatment of gangrene depends upon the cause of the particular form, but it will be of advantage to refer here to some general principles. From what has been said as to the difference in the symptoms in moist and dry gangrene, it is evident that if the gangrenous part be not removed, the most important point in the treatment is to try to prevent the septic decomposition which will otherwise take place, and from this point of view it is important to favour the production of the dry form as much as possible. Hence, if it be suspected that gangrene is about to occur, *e.g.* when the circulation in a part does not recover reasonably soon after embolism or ligature of an artery, the skin should be shaved and thoroughly disinfected in the usual manner (see p. 100). Special attention should be paid to the nails, which should be cut short; the folds of skin under and about them should be scrubbed with extreme care. It should be borne in mind that the organisms in dust have to be guarded against, as well as the pyogenic and other pathogenic organisms. An antiseptic dressing designed to prevent decomposition and at the same time to allow drying of the part should then be applied. The best is the one we usually employ for wounds, viz. a large mass of cyanide gauze wrung out of a weak antiseptic, such as a 1 in 4000 sublimate solution, outside which a thick layer of freshly sterilised salicyclic wool is applied. This dressing permits drying, and should not be disturbed unless it be desired to ascertain whether death has occurred, or unless discharge comes through. Above all things the use of ointments should be avoided, because they prevent the evaporation of the fluids, and so keep the gangrenous part moist. The limb should be placed on a water-pillow and slightly elevated. The question of amputation will be considered in connection with the individual forms of gangrene.

General.—Concentrated and easily digested food, such as various extracts of beef, meat juice, lean underdone minced meat, chicken, game, fish, etc., must be administered. Stimulants are usually necessary; the best is brandy, or, if there be no diabetes, champagne. Drugs, especially opium, will be required to relieve the pain, and the free evacuation of the bowels must be secured. The urine should be examined for sugar, diacetic acid, acetone, and for albumen, and if any of those compounds be found, the necessary diet and treatment must be adopted.

ETIOLOGICAL CLASSIFICATION.—We may now pass on to the consideration of the etiological classification of gangrene, according to which there are three great varieties, termed respectively, *direct*, *indirect*, and *specific* gangrene. By direct gangrene is meant gangrene of a part that has been directly subjected to an injury, as, for instance, when a cart-wheel passes over the foot and the foot dies. In indirect gangrene the gangrene occurs at some distance from the cause, as, for instance, when the foot becomes gangrenous after ligature of the femoral artery. Specific gangrene is the variety due to specific organisms, for example, phagedena, acute traumatic gangrene, and the like.

DIRECT GANGRENE.

Direct Gangrene may be due (1) to crushing of the part, (2) to pressure, (3) to acute inflammation, and (4) to the action of heat, cold, or caustics.

Gangrene due to Crushing.—The most common cause of direct gangrene is severe contusion or crushing, as, for example, when a limb has been run over. In some cases the parts which are directly subjected to injury may lose their vitality at once; in other cases, where septic inflammation occurs subsequently, tissues may die which were not killed outright by the injury itself. Further, in these cases there may be indirect as well as direct gangrene; for example, when the wheel of a heavy cart passes over the leg it may rupture the blood-vessels going to the foot, and so lead to gangrene of the toes and the foot as well as of the tissues at the site of the injury. This form of gangrene is moist, and the constitutional symptoms and local appearances depend upon whether or not it has been possible to render the part aseptic immediately after the injury.

Treatment.—In a crush affecting the extremities, it is not always easy to say at first whether the injured part will die or not; hence, when the state of the patient will permit, or when there is a doubt as to the extent of recovery, it is well to wait for a short time before amputating. Meanwhile, however, measures must be taken to prevent or diminish as far as possible the putrefaction of any portion that may die. The parts should therefore be disinfected thoroughly (see p. 100), and a dressing applied and left on for twenty-four or forty-eight hours, till it is seen how much tissue is going to die. An additional advantage of delay is that the patient may recover from the shock of the accident before he is subjected to the shock of the amputation; one of the great dangers of primary amputation is the addition of the shock of the operation to that caused by the injury.

The *question of amputation* depends upon the amount of injury done. In some cases there is no object in waiting, because it can be seen at once that the injury is irreparable. For example, when not only the skin but also the bones, vessels, and nerves are destroyed, there can be no question as to the advisability of amputation. On the other hand, if the blood-vessels and nerves be intact, it may still be possible to save the limb, even though the bones be extensively crushed, and a large area of skin destroyed, provided always that the wound be rendered aseptic. Formerly, amputation was performed if the bones were extensively injured, even though the large vessels and nerves were intact; but sufficient experience has shown us that a large number of cases of compound fracture can now be safely treated under antiseptic precautions, without recourse to amputation. Formerly, also, it was held best to amputate when large portions of the skin were lost, even though both vessels and bones were intact, because violent inflammation and septic absorption often occurred and led to a fatal result; if the patient survived, either the wound did not heal at all, owing to the difficulty of contraction, or if it did, the contraction caused great deformity, and rendered the extremity useless. At the present time, however, these risks can be avoided to a certain extent, and amputation is not always necessary even when extensive areas of skin are lost. In the first place, if asepsis be obtained, it frequently happens that a considerable amount of tissue which would otherwise have died retains its vitality. In the second place, the great contraction which would otherwise result is avoided by the use of skin-grafting when the wound has begun to granulate (see p. 52), while at the same time wounds can be got to heal which otherwise would not heal at all. In patients who are very old, or much broken down in health, and to whom a long confinement to bed would be injurious, more particularly if they are the subjects of renal disease, amputation, however, is often the safest procedure. When diabetes is present, the cases in which an attempt should be made to save the limb are comparatively few.

Gangrene due to Pressure.—Another cause of direct gangrene is continued pressure, and it is very important to remember this when a patient has to be kept in one position for a long time. Under such circumstances, the parts subjected to pressure are apt to die, and this is especially the case with soft parts over bony prominences, such as the sacrum, or those subjected to pressure against the edge of a splint. This is the condition known as **bed-sore**. The gangrene in these cases is moist.

Treatment.—The treatment of bed-sore resolves itself into (*a*) prophylaxis, (*b*) treatment when bed-sore is threatened, and (*c*) when it is actually present.

Prophylaxis.—The essential points in the prophylactic treatment are in the first place to avoid continuous pressure, or to so vary or diffuse it that it shall not tell too long or too injuriously on one part, and, in the second place, to keep the skin dry. The first indication is carried out by frequently *altering the position* of the patient or the part, or by so arranging matters that the pressure shall not tell on any bony prominence. For instance, the patient may lie on a ring-pillow, the opening in the pillow being opposite the part which is to be relieved of pressure.

Another, and in most cases the best, way is to place the patient on a *water-pillow or a water-bed,* so that the pressure does not remain localised to any one point, but is distributed over a considerable area. When a water-pillow is used, it must be neither over- nor under-filled; in the former case, it becomes hard and convex, and does not apply itself evenly to the skin, so that as much pressure is exerted upon the part as if there were no water-pillow at all. On the other hand, if there be too little water, the patient is not properly supported, and the part comes into contact with the bed. A good method of testing the filling is to bear one's whole weight on the pillow by pressing the two spread-out hands in the centre; if they just touch the other side of the water-pillow, the patient's body will float when laid upon it. A large water-pillow must be filled upon the bed. The water should be tepid when introduced, and it ought to be changed every three or four days, otherwise it is apt to become foul. The pillow is covered by a draw-sheet, and great care should be taken that this does not become wrinkled. When the pressure is only over a limited area, or the patient is a small child, an *air-cushion* may be used for the same purpose.

A second point in the avoidance of bed-sore is to see that the parts most exposed to pressure are *kept dry*. The patient should be turned over twice a day, and the sacral or any other region subjected to pressure, should be carefully washed and dried; after this the part should be rubbed gently with a soft towel so as to improve the circulation, and the nutrition of the tissues should be further promoted and the epidermis hardened by the application of some stimulating fluid, such as spirits of wine or whisky. The spirits of wine is allowed to dry on the skin, which is then gently chafed, and subsequently dusted with boric acid powder.

When a bed-sore is threatening—that is to say, when the skin is becoming red—the same measures should be continued, but it is well to relieve the pressure entirely by placing a ring-pillow around the part on the surface of the water-bed. When the skin is becoming raw, lint spread with equal parts of balsam of Peru and resin ointment is a good application; it should be renewed night and morning, after the part has been washed, dried, and rubbed with alcohol.

When a bed-sore has formed, the slough, and subsequently the sore, must be kept as aseptic as possible. When the patient is lying on the affected area it is impossible to carry out one of the chief principles in the treatment of gangrene, namely, to favour the drying of the slough, and, that being the case, there is no objection to the use of antiseptic ointments. Full-strength boric or eucalyptus ointment may be used and should be changed for the half-strength boric ointment when the slough has separated. Balsam of Peru, either alone or mixed with an equal quantity of white of egg, is also a good dressing. As soon as possible the patient should be made to lie upon one side, when the sore will usually begin to heal, unless the general condition be extremely feeble. The patient's general nutrition should be promoted by the administration of light and easily digested food and stimulants.

Gangrene due to Acute Inflammation.—When an acute inflammation occurs in dense tissues, and especially when it ends in suppuration, not only may the toxins kill the tissues, but the thrombosis and the pressure of the exudation on the blood-vessels may also lead to their death from insufficient blood-supply. The best examples of this are acute necrosis following acute suppurative periostitis and osteomyelitis, and the sloughs which occur in the skin in boils and carbuncles. These cases will be dealt with under their respective headings; we need only say here that early free incisions are called for.

Gangrene due to the Action of Heat, Cold, or Caustics.—The treatment of this form of gangrene is practically that of burns and scalds and frostbite (see Chap. VIII.).

INDIRECT GANGRENE.

In the indirect form of gangrene the causal agent does not act directly upon the part which dies, and this form of the affection may be divided into the four following groups, viz.: (1) gangrene due to gradual diminution in the calibre of the blood-vessels; (2) gangrene due to the sudden obstruction of the blood-vessels; (3) gangrene due to imperfect innervation; and (4) gangrene due to general causes, such as diabetes, acute fevers, the use of ergot, etc.

Gangrene due to the Gradual Diminution in the Calibre of the Blood-vessels.—*Dry or senile gangrene* is the typical example of this form. The changes leading to senile gangrene affect the arteries, and are in part gradual diminution in the calibre of the blood-vessels, and in part rigidity of their walls, so that they do not dilate and contract in conformity with the needs of the tissues. Anything which leads to endarteritis will favour the production of this form; for example, alcoholism is a very potent cause of endarteritis, as are also chronic nephritis, diabetes, and syphilis, and these are among the chief causes of senile gangrene. Another common cause is atheroma, which is a chronic inflammation of the deeper part of the internal coat of the artery, leading to irregular thickening and rigidity, diminution in calibre, and even in some cases calcification of the middle coat. In atheroma and endarteritis a further cause of gangrene is the readiness with which thrombosis occurs in the affected vessels, and leads to complete blocking of their lumen.

It is evident that in most cases certain symptoms, due to imperfect blood-supply, will precede the occurrence of the gangrene. Thus, one of the chief complaints of the patient, even long before the gangrene occurs, is great coldness and perverted sensation in the feet. He suffers much from tingling, he does not feel the ground properly when he walks, he feels, in fact, as if there were something soft between his feet and the ground. After these symptoms have lasted some time, something occurs which sets up a little inflammation about the foot; possibly a blister forms as the result of tight boots, or a corn suppurates, or the tissues are injured in paring a corn. Some trivial cause leads to inflammation, and, on account of the weak state of the tissues, this is followed by gangrene; had the tissues been healthy, the inflammation would have passed off without any trouble. The first sign of gangrene is usually a small black spot which occurs in the centre of the inflamed area. The gangrene progresses very slowly, and it may be weeks or even months before more than the toes die. The appearances are those typical of dry gangrene (see p. 67). The patient for some time remains in a good state of health, and his chief complaint is the pain he suffers, which may be intense. As the result of this, he becomes sleepless, and after a time his pulse loses its fulness, and he gets restless. If the disease be allowed to run its course, the patient will in most cases die, worn out by pain and want of sleep, or from some septic complication which has its origin at the line of demarcation. In some cases, however, recovery takes place; the line of demarcation forming very slowly, and the dead part being cast off gradually.

Treatment.—In describing the treatment of this form of gangrene, it is necessary to consider the *prophylactic treatment* as well as that called for when gangrene has actually set in. When an elderly patient complains of symptoms indicating imperfect circulation in the foot, and when on examination the vessels are found to be thickened, or devoid of pulsation, pains should be taken to explain the danger, and to point out how slight are the injuries which may precipitate the onset of gangrene. The patient must not wear tight boots, and should be specially cautioned not to neglect any injury to the foot, however trivial it may appear. Above all he should be warned not to place his feet in hot baths or before a very warm fire, for the heat is apt to bring on gangrene owing to the imperfect state of the circulation. If his feet be very cold, he may place them in a bath of from 80° to 85° F., tested by a thermometer, and then have them gently rubbed with a soft bath-towel. He should wear warm stockings, and warm, light, fur-lined shoes or slippers. In bed he should wear thick bed-socks, and the bed may be warmed with hot bottles, which however should either be taken away before he gets into bed, or removed to such a distance that his feet cannot reach them; in all cases the bottles should be wrapped up in thick flannel. The diet must be nourishing, and plenty of fresh air and light exercise should be insisted upon.

Directly gangrene has occurred, or rather as soon as it is evident that it is inevitable, the first essential in the treatment is to disinfect the part thoroughly and to favour evaporation of fluid from the tissues (see p. 68). Above all things, ointments, carbolic oil, and other greasy dressings should be avoided, and only those employed which permit drying of the part; cyanide gauze next the skin, with some sterilised salicylic wool outside, forms the best dressing. The patient should remain in a recumbent position, with the foot kept warm and slightly elevated. The strength must be supported by generous diet and fresh air, obtained if possible by wheeling the patient out in a suitable reclining chair every day. The heart's action must be assisted as far as possible, and for this purpose the tinct. nucis vomicæ in 5-minim doses, combined with 5 minims of the tinct. digitalis, three times a day, is valuable. The free administration of opium is called for in order to relieve the pain; this drug has a very beneficial effect in many cases of senile gangrene, even when there is no diabetes. It probably acts mainly by relieving the pain, and thus enabling the patient to get sound rest and sleep; but some authorities consider that opium has a specific action in gangrene. It should be given four times a day, beginning with 10 to 12 minims of laudanum, or pil. saponis co. (gr. 5–10), and gradually increasing the dose. At the same time the bowels must be kept open by the use of one of the natural aperient mineral waters, or by Seidlitz powders and enemata. Stimulants will probably be required, certainly in the later periods; whisky and brandy, in amounts from 3 to 6 ounces daily, are the best.

At an early period the *question of amputation* must be carefully considered. The old rule was that amputation should never be performed in senile gangrene, but that the part should be allowed to drop off, the utmost surgical interference allowed being to snip through dead tendons or bones; on no account was interference with the living tissues allowable. The reason for this was that before the antiseptic era acute inflammation almost always followed amputation, and when inflammation occurs in these weak tissues it is almost certain to lead to sloughing of the flaps and more rapid progress of the gangrene, which then becomes of the moist variety. At the present time, however, it is easy to avoid this inflammatory disturbance, and therefore the rules as regards amputation in senile gangrene are completely altered. It is now not so much a question of recurrence of gangrene in the stump, as whether the patient has sufficient recuperative power to recover from the operation. In cases where the answer to this question is doubtful, it must be remembered that the patient, if left alone, will almost certainly die from the senile gangrene, and therefore that amputation offers practically the only chance. By operating early, and by amputating well above the dead part, the patient's strength is preserved, he is not worn out by pain and loss of sleep, and he is in a much better condition to survive the operation than if it were delayed. The only difficulty is that it is not always possible to gauge how far the process will extend; as a rule, this can be determined by ascertaining the point at which pulsation in the main vessels ceases. In some rare cases in which the artery can be felt beating strongly at the ankle joint, amputation may be performed there, preferably by means of an internal flap. In most cases the pulsation at the ankle is very slight, if present at all, and when it cannot be felt there the best place for amputation is the region of the knee. The thrombus which forms in the diseased vessels when the amputation is done through the ankle is apt to extend upwards as far as the knee and lead to gangrene of the flaps. Generally, therefore, amputation through the condyles of the femur or the lower third of the thigh is preferable.

Gangrene due to Sudden Obstruction of the Blood-vessels.—This may be the result, firstly, of pressure outside these structures, for example, after ligature, the application of tight bandages, pressure from the fractured ends of bones, etc.; secondly, of rupture of their walls, as in dislocations or in the attempted reduction of dislocations; and, thirdly, of blocking of their lumen, as by an embolus, followed by thrombosis.

In the first two cases the vein may be blocked as well as the artery, and while this makes no essential difference in regard to treatment, the symptoms vary somewhat. When the obstruction is primarily arterial, the first thing noticed is that the limb below becomes pallid from absence of blood; it then assumes a dark livid colour, and the various changes already described as characteristic of moist gangrene follow. In embolism there is, in addition to the sudden whiteness of the limb, violent pain at the point where the embolus has been arrested, and this is a valuable sign as showing where the block has occurred. When, however, the case afterwards comes to amputation it must not be assumed that the seat of pain is the upper limit of the obstruction, because thrombosis takes place subsequently to the embolism, and may extend upwards for a considerable distance. If there be venous as well as arterial obstruction in the first instance, the part below remains dark and becomes œdematous very quickly.

Treatment.—This depends on the extent of the gangrene, and the great question for consideration is that of amputation. Before deciding this point, sufficient time should be allowed to elapse to enable the surgeon to see how much of the collateral circulation will be established, because, although at first the part may appear white and dead, a very considerable portion, or indeed the whole, may recover as the result of the enlargement of the anastomotic circulation. While waiting however, precautions must be taken not to allow putrefaction to occur, and also to permit drying (see p. 68). If gangrene occur, the part soon becomes dusky and remains cold. The finger firmly pressed into the skin makes no difference to the colour; whereas, if the circulation be maintained, the part pressed upon becomes white and regains its original appearance when the pressure is discontinued. When recovery takes place, it does so within the first twenty-four hours, and amputation should be practised without further delay when it is certain how much is going to die. There is no necessity to wait for the formation of a line of demarcation.

The point at which amputation should be done depends on the anatomy of the arteries and on the extent of recovery. It should, however, be borne in mind that the gangrene is generally less extensive in the skin than in the deeper parts, and therefore if the flaps be cut close to the gangrenous part, the incision will probably go into dead tissues as it is deepened. Hence an interval of at least three inches should intervene between the line of gangrene and the amputation incision (see Fig. 22). In many cases, however, amputation is done higher up than this on account of the better stump obtained, or on account of the better anastomotic circulation. When there is blocking of the veins as well as of the arteries, the chances of restoration of the local circulation are less, but the rules of treatment are the same.

Fig. 22. — Diagram to illustrate the Principles of Amputation for Gangrene of the Leg.—The shaded portion represents the extent of the gangrene, which is seen to extend further up the limb in the deeper tissues than in the skin. The unbroken lines above this represent the incisions which must be made in order to remove the whole of the gangrenous area. In many cases much more healthy tissue must be removed.

Gangrene due to Imperfect Innervation.—When a limb is paralysed, its nutrition is almost always deficient, and such limbs are especially liable to the formation of bed-sores and gangrene from pressure. In hemiplegia also, when the patient is lying absolutely still, he is extremely liable to suffer from bed-sores, which are worse on the paralysed side than on the sound one. Again, if extension be applied to a paralysed limb and to a sound one, there is much greater liability for sloughs to form under the extension plaster on the paralysed limb than on the sound side.

The gangrene that occurs in these cases generally comes on very quickly. It is moist, and is often spoken of as an **acute bed-sore,** and it is very important to remember that under such circumstances the greatest care should be taken to avoid even the slightest pressure. The part must be examined frequently to see that its condition is good, and the limb should be kept warm and slightly elevated; should sloughing occur, the case must be treated like one of bed-sore (see p. 70).

There is another form of gangrene in connection with nervous derangements termed symmetrical gangrene or **'Raynaud's Disease.'** This form differs from senile gangrene, which it resembles in some respects, in that it is always bilateral, while senile gangrene is often one-sided; that it more often affects the fingers than the toes; that it is much more limited both in extent (generally not reaching beyond the phalanges) and in depth (seldom going deeper than the skin); and that in 'Raynaud's disease' the blood-vessels are structurally normal, whereas in senile gangrene they are thickened and hard. 'Raynaud's disease' occurs chiefly in women of pronounced neurotic type between eighteen and thirty years of age; though often associated with uterine and menstrual troubles, there is little evidence of a closer causal connection than that both are referable to profound vaso-motor disturbance. The attacks are often brought on by cold, and are most commonly met with during the winter months. It is probable that in some cases the disturbance is in the vaso-motor centres, in others in the vaso-motor nerves, and yet again in others in both centres and fibres simultaneously. The initial effect would seem to be spasm of the arterioles of the extremities. In the asphyxial stage there is vaso-paresis of capillaries and veins, side by side with or following upon arterial vaso-constriction. Not only the ischæmia of the spasmodic stage, but also the hyperæmia of the asphyxial stage may terminate in gangrene.

Certain phenomena precede the gangrene. The extremity affected may become quite white from contraction of the blood-vessels; following this, or occurring without any preliminary pallor, the parts may become of a deep purple colour, as though dipped in ink. This is evidently due to a local venous stasis and it may last for a day or two, and may or may not lead to dry gangrene. The darkness of the extremities just noted continues for some days, the pain and other symptoms increase, and small bullæ may possibly form; indeed, in the case of the hand, it often looks as if the patient must lose all the fingers. Ultimately the circulation improves, and as a rule the final result is that only a small piece of tissue dries up, and ultimately separates. The process is slow and takes from twenty days to ten months from the commencement of the gangrene to the separation of the slough. The condition is very apt to recur.

Local Treatment.—In the treatment of the local condition, the first place must be given to stimulation by the electrical current. For this purpose the *constant current* may be used, and, as recommended by Sir Thomas Barlow, the extremity of the affected limb should be immersed in a basin of salt and water. One pole of the constant current battery is placed on the upper part of the limb, whilst the other is immersed in the fluid in the basin. As many cells may be employed as the patient can comfortably bear, and the current is made and broken twenty to thirty times per minute, so as to get repeated muscular contractions. When several extremities are affected, and it is possible to obtain it, the complete electric bath is best.[1] This should be of porcelain, earthenware, or wood, about 5 ft. 6 in. long, and the patient should be immersed in it up to the neck. The water should be just under 100° F. The electrodes are large flat copper plates about a foot square; they are placed at the head and foot of the bath. The shoulders should not touch the electrode, the feet may be allowed to do so. The current at first should not exceed 100 milliampères; after a few baths it may be gradually raised to 150 or 200, and it should not be turned on until the patient has been in the bath some little time, and then only very gradually. The

[1] For further information on these points the reader is referred to Dr. Lewis Jones's *Medical Electricity* (H. K. Lewis, London).

bath should last about fifteen minutes, and should be repeated daily for the first week; then three times a day until about a dozen to fifteen baths have been taken. This is generally sufficient to produce considerable improvement. Another method is to rub the limb over with two sponge electrodes held a short distance apart; this is useful in reducing the pain that is usually present. This method may also be employed, when gangrene has actually occurred, for the relief of pain in the surrounding parts.

The application of the current generally produces a somewhat profuse perspiration, and is usually unaccompanied by pain; an important change, showing that the current is doing good, is that the hands frequently become moist, where previous to its application they were harsh and dry. This, by Raynaud himself, is considered one of the most favourable elements of prognosis. He also points out that when this treatment has been followed for some days, and improvement has distinctly commenced, certain unpleasant effects may begin to manifest themselves; for instance, headache, which is intensified by the passage of the current, a painful sensation of constriction in the throat, and general excitement. He states that these symptoms are not serious, but that, should they occur, it is proper to diminish the strength of the current.

Another very useful form of treatment, and one that may often be advantageously combined with the use of electricity, is careful *friction* or shampooing. In some cases this cannot be borne by the patient, however carefully it be carried out; but it will generally be found that after electricity has been employed for some little time in the manner just recommended, the parts are sufficiently free from tenderness to bear careful shampooing with the hand encased in soft flannel or other suitable gloves. After a time friction by the naked hand, anointed with some simple lubricant, may be substituted. This may also be used with advantage for those cases in which, after repeated attacks of gangrene, the limb has become contracted and anchylosis has occurred. Under these circumstances it is of course used with a different object, namely, to promote the nutrition of the muscles and to facilitate the movement of the various joints. The friction may be carried out immediately after the application of the current, and may be repeated more than once during the day if the patient experiences definite relief from its use.

In cases in which, during the height of the spasm, there is intense pain, considerable relief seems to be afforded by the application of slight *cold*, and this appears to be more effectual, at any rate in abating the pain, than the use of hot fomentations. For this purpose the extremities may be covered with a piece of lint dipped in eau de Cologne, or some similar spirit, diluted with water. In cases of extremely grave local asphyxia, when gangrene was obviously impending, Raynaud made use of the application of leeches with apparently satisfactory results. This method, however, should not be employed except when the condition is grave, as with it septic complications are not at all unlikely to occur. Whenever it appears imperative to relieve the local congestion, we should prefer to use scarifications (after the skin has been rigorously purified) followed by warm fomentations to encourage bleeding.

General Treatment.—Much may be done to prevent recurrence by attention to the general health. Warm clothing and avoidance of cold are of prime importance; only second in importance to these are nourishing food and regular daily exercise. If there be a marked hysterical condition, the patient may be treated by massage and careful feeding, combined with isolation, as recommended by Weir Mitchell. Apart from this, some drugs seem to be of benefit, although there is apparently none that can be looked upon as having any specific effect upon the affection. Chief among these is *opium*, which is useful in some cases. Possibly it may allay the spasm to a certain extent; at any rate it calms the agonising pain that is often present. *Quinine* in doses of four grains three times a day is also of use both constitutionally and for the local condition. If there be pronounced anæmia, *iron* and *arsenic* may be administered, the former as Blaud's preparation in capsules of five to ten grains three times a day, the latter in the form of Fowler's solution, beginning with a dose of three drops upon a piece of sugar taken three times a day, and gradually increased until twelve or fifteen minims are taken at a time. *Nitrite of amyl, nitro-glycerine* and *nitrite of sodium* have been recommended from a theoretical consideration of their action, but apparently without any marked benefit. Any uterine or ovarian trouble present should receive appropriate treatment. When actual sloughing has taken place, the treatment already described for dry gangrene must be carried out, antiseptic dressings being used, and the part allowed to dry up. Amputation is rarely necessary.

Gangrene due to General Causes.—This form of indirect gangrene is in some ways the most important of all. Three varieties may be mentioned, namely (*a*) gangrene in connection with diabetes, (*b*) gangrene after acute fevers, and (*c*) gangrene following the use of ergot.

Diabetic Gangrene.—There are two ways in which diabetes may be related to gangrene. First, there is the death of the part directly dependent upon the presence of diabetes, or the true 'diabetic gangrene'; second, there is gangrene from some other cause taking place in a patient who has glycosuria. The presence of glycosuria affects the progress of the gangrene in a marked degree; it spreads with greater rapidity, there is more inflammation around the gangrenous part, and the gangrene, if dry at first, soon becomes moist. The patient generally dies either of some septic complication—such as a rapidly-spreading diffuse cellulitis or a general septicæmia—or of diabetic coma, either following operation or occurring independently. Sometimes the gangrenous process is slow and the patient dies of exhaustion.

Diabetes leads to gangrene, in the first place, because it gives rise to endarteritis, and consequent diminution in the calibre of the vessels; and in the second place, because the tissues of the diabetic are less able to resist injury than healthy ones; they are especially sensitive to the pyogenic organisms which appear to grow in them with special rapidity and virulence. Some authorities also hold that the innervation of the tissues is interfered with as the result of central nervous disturbance, and that they are thus predisposed to gangrene.

Treatment.—Bearing in mind the great tendency of their tissues to gangrene, diabetics must be specially warned to avoid any injury, however trivial, lest acute inflammation, which may become gangrenous, should follow; more especially they should avoid slight injuries to the feet, the wearing of tight boots, etc. Strict asepsis should be employed in the case of any wound from which they may suffer, and when gangrene has set in, the usual treatment should be adopted, namely, the disinfection of the limb and the application of an antiseptic dressing (see p. 68).

General.—The patient must be placed on anti-diabetic diet, that is to say, he should avoid substances that lead to the production of sugar, such as sugar itself, all starchy foods, potatoes, etc. The stringency of the diet must depend on the amount of sugar in the urine and the condition of the patient; if he be very weak it is inadvisable to put him suddenly on too strict a diet. The following dietary, for which we are indebted to Dr. Burney Yeo,[1] will give full details as to the diet of a diabetic patient.

SEEGEN'S DIETARY.

Sanctioned.

IN ANY QUANTITY—Flesh of all kinds; preserved (smoked) meats, ham, tongue, bacon; fish of all kinds; oysters and shell-fish; crabs, lobsters; animal jellies; aspic; eggs, caviare, cream, butter, cheese; spinach, cooked salads, endive, cucumber, green asparagus, watercress, sorrel, artichokes, mushrooms; nuts.

IN SMALL QUANTITY—Cauliflower, carrots, turnip, white cabbage, green beans; berries, such as strawberries, raspberries, currants; also oranges and almonds.

BEVERAGES.

IN ANY QUANTITY—Water, soda-water; tea, coffee; Bordeaux, Rhine, and Moselle wines; Austrian and Hungarian table wines. In short, all wines that are not sweet, and that contain only a moderate amount of alcohol.

IN VERY SMALL QUANTITIES—Milk, unsweetened; almond emulsion; brandy, bitter beer; lemonade, unsweetened.

[1] *A Manual of Medical Treatment or Clinical Therapeutics* (Cassell & Co., London)

Forbidden.

Farinaceous foods of all kinds (bread only in very small quantity according to the discretion of the physician); sugar; potatoes, rice, tapioca, arrowroot, sago, groats; peas, beans; sweet fruits, as grapes, cherries, peaches, apricots, plums, and all kinds of dried fruits.

BEVERAGES.

Champagne and sweet wines and beers, must, fruit wines and fruit juices and syrups; sweet lemonade; liqueurs; ices and sorbets; cocoa and chocolate.

Opium, or still better, *codeine*, should be administered in large quantities. The codeine is given in doses of a quarter of a grain three time a day, which is gradually increased up to five grains. Stimulants may also be necessary if the pulse is becoming weak, and the patient exhausted; the best are dry wines, such as dry sherry or whisky in small quantities; sweet wines should be strictly avoided.

Local.—Question of Amputation.—This arises at an early period. Formerly the rule was not to amputate in diabetic gangrene, partly on account of the great tendency to inflammation and suppuration in the stump, leading to extension of the gangrene, and partly owing to the risk of death from diabetic coma. This rule, however, has been completely altered by the introduction of antiseptic measures, and from recent work it seems quite evident that the best treatment in most cases is early amputation. If left alone, the majority of patients die. By strict asepsis inflammation in the stump is avoided, septic troubles are prevented, and an extension of the gangrene does not occur if the amputation be performed sufficiently high up. For example, if the gangrene has only extended to the foot, the amputation may be carried out at the seat of election or a Lister's amputation in the lower part of the leg may be performed, provided that there be no marked arterial change and no evidence of pus spreading up the leg. If either of these complications be present, the amputation should be performed through the condyles of the femur or in the lower third of the thigh.

The principal risk is from diabetic coma. The risk of this very fatal complication is undoubtedly increased to some extent by the use of an anæsthetic, more especially of chloroform; for this reason many surgeons prefer to employ spinal anæsthesia (see p. 486). On the other hand, the patient is not really more liable to an attack of diabetic coma after amputation *per se* than he is during the course of the gangrene. In any case the risk of operation is not so great as the risk the patient runs if left unoperated upon.

Gangrene after Acute Fevers.—Gangrene from this cause is sometimes a sequela of typhoid fever, and attacks the extremities and the parts farthest from the heart, especially the toes, the nose, the ears, and sometimes the fingers. This form of gangrene is generally due to endarteritis and thrombosis; in some cases, however, it follows embolism. It usually begins during the period of convalescence and is of the dry variety.

Treatment.—The treatment is to disinfect the part, apply an antiseptic dressing (see p. 68), and, in the case of the extremities, to wait for a line of demarcation before amputating, partly because the exact amount of tissue that will die cannot be known, and partly because the patient's condition is generally so bad at the onset of the gangrene that amputation would be very apt to cause death. In addition, it is important to support the patient's strength and treat any symptoms that may arise.

Gangrene from Ergot.—This form of gangrene may occur in epidemics, when the rye in certain districts has become infected with the ergot fungus (*claviceps purpurea*) and when families eat large quantities of this infected rye in the form of rye-bread. The early effect of ergot is to produce tonic contraction of the smaller blood-vessels, and if this be kept up for a long time, it may lead to gangrene, more especially of the extremities.

Certain symptoms, such as diarrhœa, buzzing in the ears, cramps, coldness of the extremities, etc., precede the occurrence of gangrene. The affection usually attacks men between thirty and forty years of age. The form of gangrene is usually dry, but in certain cases it may be moist, and it may vary in extent from the loss of a nail to the loss of a limb.

Treatment.—In the first instance the cause should be removed. If there be the premonitory symptoms of ergot poisoning, or the epidemic occurrence of gangrene in young patients who are otherwise healthy, the food must be examined, and if the claviceps be present, untainted bread must be substituted. Great attention should be paid to the nutrition of the patient, and the use of strong coffee is highly recommended as an antidote.

When gangrene has set in, the patient must be kept in bed, and the part disinfected and kept aseptic and dry; before deciding on amputation, a line of demarcation should be waited for, because it is impossible to say how much of the tissue will die. As a rule, the line of demarcation is permanent when it has once formed, and therefore, the best method of fashioning the flaps can be decided upon and amputation performed without any further delay as soon as it is well-marked.

INFECTIVE GANGRENE.

The third great group of gangrene is that due to specific infective organisms. In former days, a variety of gangrenous processes attacked wounds as the result of sepsis, but they are seldom seen now. It will be sufficient if we speak here of three forms of specific gangrene, namely: (1) acute traumatic gangrene; (2) phagedena; and (3) cancrum oris or noma.

Acute Traumatic Gangrene.—This is a form that attacks wounds and is due to the growth of bacteria in the tissues ; it especially attacks wounds which have been soiled with earth. The emphysematous form of the affection is probably most often due to the presence of a gas-producing organism, the *bacillus aërogenes capsulatus*, but the bacillus of malignant œdema may produce similar symptoms without much gas in the tissues ; there are probably other organisms also concerned in some of these cases. The disease usually begins about the second or third day after the accident. As a rule, its course is very rapid, averaging about three days before the death of the patient ; the part becomes greatly swollen and œdematous and generally crepitates from the presence of enormous quantities of gas developed in the tissues. The constitutional symptoms are always severe, the temperature is usually high, the pulse rapid and ultimately irregular. In addition to this there is great prostration, the patient's condition passing rapidly into the 'typhoid state.'

Treatment.—The first point in the treatment is *prophylaxis*. When wounds are soiled with earth or dirt, especial care should be taken to disinfect them, and the best plan is to place the patient under an anæsthetic, to scrub out the earth with a nail brush and 'strong mixture' (see p. 50), and then to apply undiluted carbolic acid to the whole surface of the wound. It must be remembered that acute traumatic gangrene is not the only disease which results from the soiling of wounds with earth, malignant œdema and tetanus being often produced in a similar manner. Hence thorough disinfection of such wounds is imperative.

Local Treatment.—In acute traumatic gangrene of the extremities, *amputation* at the highest possible point offers the only chance of saving the patient. Almost all the patients attacked by this affection die, and unfortunately even after amputation only about 5 per cent. recover, because it is extremely difficult and often impossible to get above the disease except at a very early stage. In amputating, the greatest care must be taken to disinfect the skin, and especially to avoid soiling the amputation wound with the discharge from the gangrenous part. Hence, in addition to the ordinary disinfection of the skin at the seat of amputation, the gangrenous extremity should be wrapped up in antiseptic gauze wrung out of the strong mixture, and then enveloped in sterilised jaconet or mackintosh firmly fastened round the limb, well above the upper limit of the gangrene, so that none of the contents of the bullæ, etc., can run out. This is done by an assistant who is not afterwards allowed to take any part in the operation. In operating on these cases the use of all other measures employed in the prevention of shock (see Chap. VI.) will probably be called for. In these cases, too, it is important to avoid the use of a general anæsthetic, and spinal anæsthesia (see p. 486) finds a very useful application.

After the operation, the flaps should be left open, two or three loose stitches at most being inserted. If the patient survive, the wound can be sewn up as soon as the flaps have granulated and it is evident that the specific infection has been removed, or its effects are at an end.

In some situations, the highest amputations that can be performed, that is to say at the shoulder or hip joint, may still leave tissues either certainly, or probably, infected, and in these cases free incisions must be made into the infected area beyond the line of amputation in the manner recommended for the treatment of cellulitis. For example, after an amputation through the shoulder joint, the tissues of the chest wall or even the flaps may need to be freely incised and in some cases this has proved successful.

Phagedena.—Phagedena is a disease practically never seen nowadays, but was formerly very common, especially in times of war. It is undoubtedly a parasitic affection, but the exact nature of the organism is unknown. It consists essentially in the production on the wound of a pseudo-membranous material, beneath which the tissues ulcerate or become gangrenous, and two forms, namely, an ulcerative and a gangrenous one, are usually described. In the ulcerative form a pulpy membrane appears on the surface of the wound; beneath this, cup-like losses of substance occur, and subsequently rapid ulceration takes place along the planes of the tissues. In the other form, the wound becomes covered with a thicker membrane, which is dark coloured, very pulpy, extending rapidly, leading to sloughing of the skin and muscles, and not uncommonly attacking the vessels and giving rise to severe hæmorrhage. The disease spreads with great rapidity, and the patient usually dies in from twenty-four to forty-eight hours.

Treatment.—The *prophylactic* treatment consists of strict antiseptic precautions in cases of all wounds, isolation of the affected individual, and great care not to infect other persons with the instruments, or by the attendants. Rubber gloves must always be worn by everyone who has to deal with the dressings in these cases.

In the *local treatment* the chief reliance is placed on destruction of the pulpy material, either by the application of the actual cautery, or by the use of nitric acid (see p. 85) or the liquor ferri perchloridi; of these the actual cautery seems to be the most efficacious. The parts are thoroughly destroyed with the cautery at white heat, wherever there is the slightest suspicion of the presence of the membranous material. The wound is then packed with boric lint dipped in 1 to 5 carbolic oil. If perchloride of iron be used, the wound should be first dried, and then lint soaked in the perchloride is packed into it and left for four-and-twenty hours, after which it may be dressed with boric lint and carbolic oil. The perchloride of iron has not a very powerful effect in this disease, and should only be employed when it is slight in extent and is not spreading rapidly. If the part affected be an extremity, amputation should be performed, provided it be possible to get well above the disease. Naturally, great care must be taken not to infect the stump.

The *general condition* of the patient needs the most careful attention. Stimulants, strychnine and tonics should be freely administered, and every effort made to maintain the patient's strength.

Cancrum Oris.—Cancrum oris is a disease affecting children, and beginning in the mouth or the vulva (when it is termed 'noma'). It generally attacks weakly children of from two to five years of age, who are convalescing from some other affection, such as measles or scarlatina. In the mouth, it usually begins in the gums; the patient complains of pain, the breath becomes fœtid, and there is increased flow of saliva. Ulceration then occurs about the gums, a black spot appears inside the cheek, and this extends through the cheek; a slough forms, and large portions of the jaw and cheek may be destroyed. The patient's general condition is very serious, the temperature is high, and death usually occurs in from three to four days. The disease is due to long delicate bacilli which are found in large numbers in the slough, and more especially in the living tissues just beyond it.

Treatment.—This aims at destroying all the affected parts, and the portions of the living tissues around in which the bacilli are present. All the parts which are gangrenous must be clipped away; not only the soft parts, but the portion of the jaw affected must be removed, and this should be done till a surface is exposed which bleeds everywhere. Pressure is applied to arrest the bleeding, and then strong nitric acid is painted over or rubbed into the raw surface with a stout glass rod or a glass brush. The acid is allowed to act for about ten minutes, several fresh applications being repeated during that time. When the surgeon is satisfied that every portion of the disease has been thoroughly destroyed, the action of the acid is arrested by pouring over it a saturated solution of carbonate of soda until the acid is completely neutralised. This may be presumed when bubbles of carbonic acid gas cease to form. Anything short of this treatment will fail in arresting the disease. To leave the sloughs on the surface and to apply antiseptic washes or strong antiseptics to them is absolutely useless, for the regions in which the organisms are growing are the living tissues just beyond the parts actually dead, and these cannot be reached unless the sloughs be removed first.

After the acid has been neutralised, the part should be powdered with iodoform, and full-strength boric ointment spread on butter-cloth applied with boric lint outside it. The mouth (or vagina, in the case of noma) should be washed out with sanitas and water (about 1 part in 12) several times a day. The wound will begin to granulate in five or six days, and then the half-strength boric ointment may be substituted. Stimulants are necessary, and also nourishing diet, and probably strychnine will be required at first. Great deformities are left after this disease, especially in the cheek, but the treatment of these is dealt with in connection with the plastic surgery of the face and jaw.

In addition to the specific form, two other types of gangrene occur in the mouth. In children there may be severe stomatitis leading to actual gangrene of portions of the mucous membrane of the gum. In these cases there is great swelling of the tongue and cheek, large areas of which are covered with a foul whitish membrane. The breath is very offensive; there is profuse salivation and the patient is often extremely ill for a time; the temperature does not run so high as in true cancrum oris, and the disease tends to run a more benign course. No specific organisms can be found in this condition, which is not sharply marked off from ordinary acute stomatitis. The best treatment for these cases is a mouth-wash containing resorcin. A good formula is the following:—

℞ Resorcini	gr. xxx
Potass. Chloratis . . .	gr. x
Glycerini boracis . .	ad ℥ j
Misce.	

The mouth should be frequently cleansed with weak sanitas (1 in 10) or peroxide of hydrogen (10 vols.), and the above solution should be painted all over the affected area. A brisk calomel purge should be given, and the child put under the best hygienic surroundings obtainable. A mixture containing chlorate of potash and cinchona bark may be given internally. When the disease has become quiescent, the condition of the mouth should be carefully looked to, and any decayed teeth removed or filled.

The free administration of mercury may also lead to severe gangrenous stomatitis, especially when the mouth has been allowed to remain in a septic and neglected condition. With the smaller doses of mercury now in vogue this condition is uncommon.

The treatment consists in stopping the administration of mercury and employing a mouth-wash containing chlorate of potash.

DIVISION II.

WOUNDS AND THEIR COMPLICATIONS.

CHAPTER V.

WOUNDS.

WOUNDS may be the result of accident or may be made intentionally by the surgeon. They may be divided into incised, contused, lacerrated, gunshot, or poisoned wounds, and those caused by heat and cold. Before proceeding to deal with them, however, it seems advisable to say a few words about the general management of operations.

OPERATIONS AND THEIR MANAGEMENT.

Operations may be divided into two great classes, namely, those in which the condition is urgent and the operation must be carried out without delay, and those in which some time may be allowed to elapse after an operation has been decided upon. In the latter case various preliminary steps should be taken, some of which we shall indicate.

PREPARATION OF THE PATIENT FOR OPERATION.

Certain points in the preparation of the patient are peculiar to operations in certain regions, and will be mentioned in describing those operations; such, for example, are the cleansing of the mouth and teeth before operations on the tongue and mouth, washing out the stomach before gastrostomy and gastro-enterostomy, emptying the lower bowel before excision of the rectum, and so on. But, apart from these, there are certain points common to many operations which require consideration here.

The mental attitude of the patient is of considerable importance, especially as affecting the occurrence of shock during and after the operation. When he has once decided to undergo an operation, the patient should be encouraged to look forward to a successful result ; nothing is worse for him than to feel that he is going to succumb ; shock certainly seems to intervene more quickly and more powerfully under such circumstances. Hence, although the patient and his friends should be made aware of the real danger and results of the proposed operation, the brightest side of the picture should be put in the foreground as soon as its performance has been decided on, and any drawbacks should be made light of.

There is no object in interfering with the patient's usual **diet** on the preceding day, but it is well that the evening meal should be light and easily digestible. When a general anæsthetic is to be given, food should not be given by the mouth later than three hours before the operation, and if the latter is to be performed in the early morning it is not worth while waking up the patient for a meal. If he be awake, he may have a cup of strong hot beef-tea or meat juice about six o'clock in the morning when the operation is to be performed about nine When the operation is to be a severe one, it is also advisable to give a nutrient enema half an hour before the operation.

The bowels should be well cleared out in all cases before the operation, and the most satisfactory aperient is castor oil; about an ounce should be administered overnight, followed by a plain water or soap-and-water enema in the morning. The latter is made by rubbing up Castile soap in warm water until a pretty thick lather is formed, and about a pint is injected. When the patient cannot take castor oil, or when it causes much griping, a teaspoonful of compound liquorice powder at night, followed by an enema in the morning, will generally suffice. The chief reason for clearing out the bowels, even though they may have been acting regularly beforehand, is that the patient is generally constipated after an operation and his digestion is disordered ; and, further, it is important to get rid of material which may cause trouble by decomposing, the septic products being absorbed and diminishing the patient's vitality. The evacuation of the bowels is also of importance in certain operations—for example, in piles—where steps are taken after the operation to delay their action for some time. While, as a general rule, the aperient should be given on the night preceding the operation, in some cases it is better to give it twenty-four hours earlier, and at most a simple enema on the morning of the operation. This is the case in rectal operations and in a good many abdominal sections, such as appendicectomy. If the aperient be given a few hours before, the bowels are apt to be in an irritable state after the operation and much trouble from griping pains and flatulence may result.

The most favourable time for an operation is the early morning, and that for two reasons. In the first place the patient, especially if he has passed a good night, has not so long to worry and excite himself about the operation as when a later hour is chosen ; and, in the second place, he does not miss his food. It is very important to secure a good night's rest before the operation, particularly in nervous patients, and in most cases there is no objection to the administration of a narcotic, preferably a quarter of a grain of morphine, subcutaneously at bedtime.

THE OPERATING ROOM AND ITS ACCESSORIES.

In hospitals and other large institutions, surgical operations are usually performed in *operating theatres* or other rooms specially set apart for the purpose. Although there are at present many nursing homes and private hospitals which possess operating theatres, by far the larger number of operations performed in private are done in the patient's own bedroom. At first sight it might seem as if this were exposing the patient to an unnecessary risk, but it is by no means necessarily the case. The elaborate arrangements of a large operating theatre are designed not so much for the performance of any single operation, as to enable a number of operations to be performed in safety and convenience one after the other ; and, provided that a sufficiently large and light room can be obtained, where the heating arrangements are satisfactory, an operation can be performed in perfect safety in an ordinary private house, but it is well to reproduce as far as possible the conditions of an operating theatre. There is a tendency nowadays for operating theatres to become complex, but the essentials of an operating room are in reality very simple. It should be light, warm, and readily cleaned.

The best *light* is that known technically as a studio light, preferably with a north aspect. This form of window consists of two parts, a large vertical portion which should take up the greater part of one side of the theatre and a sort of half skylight continued for two or three feet into the roof of the theatre. This provides a top light without the disadvantages of a skylight. A skylight should not be used, as it is apt to condense the moisture in the room and to allow this to drip on to the operating table or even into the wound. A good *artificial light* should also be installed, if possible from more than one source, so as to minimise the risk of its failing during the course of an operation. The lights must be arranged so as to give a brilliant diffuse illumination with no shadows.

The theatre should be provided with some *heating apparatus* other than an open fire; when this is not possible, an open fire must be used, but it has many disadvantages. While it certainly facilitates ventilation, its presence in a room where chloroform is being evaporated leads to the formation of oxidation products, which are intensely irritating not only to the patient but to the surgeon, and an operation cannot be conducted properly under such conditions. A gas fire should never be allowed, as these troubles are even more liable to occur with it. If steam or hot water heating cannot be obtained, a coal fire in an open grate should be employed. When ether is being used there is a small additional risk of fire. The temperature of the theatre should never be lower than 65° F. during an operation, but for severe cases, especially abdominal sections when a considerable amount of shock is expected, the temperature should be even higher; indeed, a temperature of 75° to 80° is often desirable. The effect of temperature upon shock is well known, but it is not as widely appreciated as it deserves to be. Under an anæsthetic the heat regulating mechanism is completely in abeyance, and a patient exposed to cold loses heat much as he would do after death.

The *walls* of the theatre should be of some easily washable material, and although a large number of cements, tilings and other wall-coverings have been introduced, there is perhaps no substance more suitable for covering the walls of an operating theatre than a good enamel paint which can be renewed cheaply and has neither cracks nor joints. The *floor* must be of some substance impervious to wet; and that form of mosaic known as 'terrazzo' forms one of the best materials. At the junction of the walls with each other, and with the floor and ceiling, there must be no angles which would be liable to harbour dust and dirt and make the cleaning of the theatre difficult; all angles, therefore, should be carefully rounded off. Where pipes run along the theatre walls, they must be fixed far enough away from the wall to allow thorough cleaning behind them; a better plan is to keep all pipes out of the operating theatre proper. In a well-constructed theatre it should be possible to play a hose over the whole of it without spoiling any of its fittings. The floor should slope slightly down to one side or to one corner, where an open gully should conduct off the waste water into the open air.

If possible, all instrument cases, sterilisers, and other fixtures should be kept outside the theatre itself in order to facilitate the cleaning of the latter. The fixtures in the operating theatre should be reduced to a minimum, nothing beyond the instruments and apparatus in actual use being in the theatre during an operation. During an operation people must not come in and out. All doors and windows should be kept closed, and the air supplied to the theatre should be passed or drawn through a thick mass of cotton wool or some other form of efficient filter.

Connected with an operating theatre of this kind there should be a series of rooms in which the various preparations connected with the operation can be carried on: for instance, a room in which the surgeon can wash his hands, an instrument and a splint room, a room for the sterilising of dressings and instruments, and an anæsthetising room are all of great importance. In addition, a recovery room is extremely valuable for the detention of patients after severe operations. This obviates any risk of exposure during the passage of the patient from the theatre to the ward.

The *operating table* may be one of the many excellent varieties supplied by the instrument makers, but the essential points are, that it shall be simple in construction, that it shall be capable of being heated either by a water-tank underneath, by a series of hot bottles or radiant electric heaters, and that it shall be possible to obtain with it the Trendelenburg position. It is also advisable for the table to be provided with a mechanism by which it can be raised or lowered. Tables for instruments, bowls of lotion, and other articles required for the operation must be provided.

In an ordinary *dwelling house*, of course, all these conditions cannot be complied with, but a room can be easily cleaned sufficiently for the the purpose, without any undue disturbance of the domestic arrangements. If possible, the room should be prepared on the day before the operation, all pictures, furniture, etc., being removed, and should not be disturbed afterwards.

When, however, an operation has to be performed as a matter of urgency, it is important not to disturb anything that is in the room more than is absolutely necessary; the removal of furniture, pictures, or carpets is accompanied by a stirring-up of the dust lying upon them, and in an emergency it is better to leave things of this nature in their original position, and cover over everything with clean dust sheets. Operating tables, basins, and other appliances can be hired from the surgical instrument makers, and when feasible, this should be done; when this is impossible, they must be extemporised. Two long dressing tables placed together, so as to form a T, make a very good operating table. The patient lies upon the one forming the vertical limb of the T with his head and shoulders resting upon the transverse one. The table should be covered by a folded blanket, over which is placed a sheet, which in its turn is covered by a mackintosh opposite the area of the operation; the whole table should not be covered. A number of bowls must be collected and, if possible, these should be boiled in a copper or large fish kettle. If a suitable vessel for boiling bowls cannot be obtained, they must be washed in a 1 in 20 carbolic or a 1 in 500 sublimate solution. One or more small tables should be covered by mackintoshes, upon which are placed boiled towels wrung out of 1 in 20 carbolic or 1 in 2000 sublimate lotion; these serve to hold the bowls, instruments, and appliances during the operation.

Important as the operating theatre is, it must not be forgotten that a very small percentage of the cases which suppurate do so because of the bad surroundings under which the operation is undertaken; indeed, operations can be and are performed with safety, or at least with a minimum risk, in badly constructed operating theatres or in the dirtiest of houses. The majority of suppurative cases originate from the introduction of organisms from the surgeon's hands, from ligatures, sponges or swabs, or from imperfect lotions and dressings.

INSTRUMENTS, LIGATURE MATERIALS AND DRESSINGS, AND THEIR STERILISATION.

Two main methods are used for the sterilisation of ligatures and dressings, viz., by means of heat and by means of chemical solutions.

FIG. 23.—GLASS JAR FOR THE STERILISATION OF CATHETERS.—This is also useful for other instruments which can neither be boiled nor immersed in an antiseptic solution. The catheters are suspended by a perforated metal plate which forms a catheter gauge; this rests upon a shoulder at the upper end of the vessel, the bottom of which is covered with a layer of formalin or 'Paraform' tablets. The jar has a tight fitting cover, so as to prevent escape of the formalin vapour.

Instruments are usually sterilised by boiling; they should be placed in a one-per-cent. solution of ordinary washing soda, which is already boiling. If the instruments be placed in this solution before it is boiled and then be brought to the boil, a deposit of lime salts takes place and the instruments are covered with a fine white powder, and are also liable to rust. All instruments should be boiled for at least fifteen minutes, but it is well to boil them longer if time permits. Many organisms are killed almost instantaneously by boiling, but there are others which are more resistant, and for safety it is necessary to continue the boiling for at least the specified time. When boiled, we are in the habit of placing the instruments in a wide flat dish, covering them with a 1 in 20 or a 1 in 40 solution of carbolic acid; this is done because, although they have been sterilised, they are none the less liable to be infected by dust or by contact with other articles, and this risk is prevented, or its evil effects are entirely avoided, by keeping them in an antiseptic solution. Knives, scissors, and needles are injured by boiling, chiefly on account of the large amount of carbonic acid in the water and the deposit of lime salts along their edges. Knives and other sharp instruments can be boiled without deterioration in distilled water but, as this is not always available in large quantities, it is usually sufficient to disinfect them by immersing them for a few minutes in undiluted carbolic acid, which is afterwards washed off in boiling water; they are then placed in the instrument trays containing the carbolic solution.

Instruments which are injured by boiling or by prolonged soaking in antiseptic solution, for example, gum elastic catheters, may be sterilised by keeping them in a jar at the bottom of which is placed 'trioxymethylene,' a substance which slowly gives off formalin vapour at atmospheric temperature; this is a perfectly efficient method of sterilising, but it takes several hours, and the formalin vapour must be of considerable strength. If the air in the top of a jar containing the trioxymethylene can be inhaled without discomfort, it can be assumed safely that its sterilising power is not very great. The lid of the jar should fit tightly; for catheters the best form is an upright cylinder with a tightly fitting ground-glass stopper and a perforated rack for the catheters to hang in.

Catgut.—The best material for and *sterilisation of ligatures* has aroused considerable controversy. We have been in the habit of using catgut, a substance which has received much undeserved condemnation, especially in this country; we have used it, however, for many years with complete satisfaction and with no bad results. Catgut is prepared from sheep's intestines and, as originally obtained, is doubtless teeming with bacteria. The first stage in its preparation is treatment with sulphurous and chromic acids [1]; this produces a tough greenish or greenish-yellow thread which will last in the body for a considerable time, usually about a month or six weeks.

This sulpho-chromic catgut is sterilised with certainty by immersing it in a 1 in 20 solution of carbolic acid for at least a fortnight, the solution being changed repeatedly and kept tightly stoppered. If more rapid preparation be required, the catgut is wound loosely round a bobbin and immersed for about twelve hours in undiluted carbolic acid; this causes the thread to become transparent much as does a microscopic specimen cleared by xylol or clove oil. It is then immersed in a 1 in 20 carbolic solution when it once more becomes opaque, regains much of its strength, and forms an efficient material for ligatures and sutures. Catgut prepared in this way can be kept unimpaired in a 1 in 20 carbolic

[1] See Lister's method of chromicising catgut: *Lancet*, February 5, 1881. The directions are as follows:—

The preparing liquid must be twenty times the weight of the catgut, so for 40 gr. of catgut 800 gr. of preparing liquid are required. It is made by mixing two liquids, viz., the chromium sulphate liquid and the sublimate liquid. The sublimate liquid is:

Corrosive sublimate . . .	gr. 2
Distilled water	gr. 320

The sublimate may be dissolved by heat, but the solution must be used cold. The chromium sulphate liquid is prepared thus:

Chromic acid	gr. 4
Distilled water	gr. 240

Add to this as much sulphurous acid (P.B. solution) as gives a green colour. If more is added, the colour becomes blue, which shows that rather too much sulphurous acid has been used. It is well to reserve a few drops of the chromic acid solution to be added after the blue colour has just appeared and restore it to green. Then enough distilled water is added to bring the green liquid up to 480 gr. Then add the sublimate liquid.

The catgut is kept twenty-four hours in the preparing liquid and is then dried on the stretch.

N.B. It is essential that the chromic acid and the sulphurous acid solutions be mixed before the corrosive sublimate solution is added.

solution for a long time. It has advantages over all other ligatures in that it is more easily absorbed and therefore can be used in septic wounds. It is absorbable like other substances only when actually in contact with the tissues, that is to say, when such a ligature is actually cast off into an abscess cavity it will remain there almost indefinitely and will be discharged with the pus; when, however, the ligature is in actual contact with the tissues it is readily absorbed. Nevertheless, it presents sufficient resisting power to enable it safely to occlude vessels and to close wounds in internal organs. It is easily tied, the knot holds well, and it is not in any way irritating to the tissues. Although much has been written of the various difficulties of sterilising catgut, we personally have experienced none of them.

Silk.—This is also much employed for sutures and ligatures. We use it mainly for sutures. It is very slowly absorbed, and as a ligature material does not possess any advantages over catgut, while it must be afterwards discharged from septic wounds. It seems to us a disadvantage to fill a wound with a large number of ligatures of a material which is not readily absorbed. Chinese or Japanese twist are the commonest varieties of silk used, the latter having a slight advantage from the point of view of strength. It should be as fine as possible, usually No. 3. Silk can be readily sterilised by boiling. The hanks supplied by the instrument makers should be loosely rewound upon glass reels or small rolls of lint; if the latter be used, the end of the thread can be secured by threading it upon a needle which is then thrust through one end of the roll, carrying the silk with it; the needle is then unthreaded and the silk cut off so as to leave about an inch of it hanging loose. About two yards of the silk, sufficient for one operation, should be wound upon each roll of lint and the pieces thus prepared are boiled for an hour without soda and are then transferred to a closely stoppered vessel containing a 1 in 20 carbolic acid solution in which they are stored until they are wanted for use. Silk prepared in this manner will retain its strength for many months; before being used it should be rinsed in a solution of 1 in 2000 perchloride of mercury.

When an aseptic ligature has been tied round a vessel, it becomes buried in lymph in the course of a few hours, and this lymph subsequently becomes penetrated with cells which organise into fibrous tissue, and which at the same time eat away the outer surface of the ligature, and penetrate between its strands, so that the ligature is ultimately replaced by young fibrous tissue. A very much longer time is occupied by this process in the case of silk than in the case of catgut, and it may be years before the silk finally disappears; sometimes small abscesses form and the silk is discharged.

Silkworm-gut.—This is a useful suture material prepared from the spinning organs of the silkworm and is supplied in pieces of varying thicknesses about a foot long. It can be boiled without impairing its strength. Perhaps the most convenient method of storing this suture material is to tie a thread around one end of a bundle of silkworm gut and to pass this through a piece of drainage tube into which the bundle of silkworm gut can be drawn by traction upon the thread. The thread is then unfastened, leaving the silkworm gut inside the drainage tube, so that one or more threads can be withdrawn as required.

Horsehair.—This is prepared by soaking it in a 1 in 20 carbolic acid solution for a week, the threads being stored for use in the same solution. If preferred, the horsehair may be sterilised by boiling. A convenient method of keeping it is to take the whole wisp of horsehair and double it in half; the loop thus formed is held firmly and its loose ends divided into three portions which are plaited together. A thread seized in the middle of the wisp can be withdrawn without disturbing the remainder.

Silver wire is readily sterilised by boiling or by passing it through the flame of a spirit lamp. In straightening a silver wire each end should be grasped firmly with a pair of forceps and twists and kinks undone by traction; friction injures its ductility so that it cannot be tied into a knot. Wire that is too brittle can have its ductility restored by heating it to redness in a spirit lamp. Fine copper or aluminium bronze wire is used by some surgeons, especially in America. It possesses considerable pliability, but we have not seen any special advantage in it over silver wire.

Kangaroo Tendon.—This material is mainly employed for ligature in continuity of large vessels such as the innominate artery. It is prepared in the same way as catgut, but it has several disadvantages—it does not tie well and, as it is of considerable thickness, the sterilising process must be very prolonged in order to be thorough, otherwise it is liable to infect the wound.

PREPARATION OF SPONGES, SWABS AND DRESSINGS.

Sponges.—The proper preparation of sponges is of great importance. In our opinion, the most satisfactory method of removing blood from a wound is by the ordinary marine sponge. In the first place, sponges absorb blood better than do the swabs that have come into fashion of late years; and in the second place, shreds of cotton are apt to be left behind in the wound when using swabs. When properly prepared, both marine sponges and absorbent swabs can be efficiently sterilised, but, as they are often prepared, swabs are quite unreliable. We have never had cause to complain of any failure of the sterility of marine sponges. Sponges should be close in texture and soft yet springy when wet; Turkey sponges are perhaps the best, but a good honeycomb sponge is almost as good. The meshes of the sponge frequently contain calcareous particles, the remains of the skeleta of numerous marine animals, and these must be removed by cutting out the larger fragments and by beating and shaking; if many of these foreign bodies be present the sponge should be rejected. The sponges are next washed in plain water containing a little soda or soap powder, to remove dirt, and are then rinsed in running water until the water squeezed out of them is perfectly clear; they are then soaked for twelve hours in a ten-per-cent. solution of hydrochloric acid to remove any remaining particles of calcareous matter, after which they are again rinsed and placed in a strong solution of washing soda overnight; after being again rinsed in clean cold water they are stored for use in a covered jar containing a 1 in 20 carbolic solution which should be changed occasionally. The sponges should not be used for at least forty-eight hours after they have been put in the carbolic. This method, although apparently rather complex, is really quite simple in practice. After an operation, the sponges are rinsed and picked clean of fibrin and other solid matter; they are then soaked for twenty-four hours in a strong solution of washing soda, rinsed thoroughly in running water and returned to the carbolic solution, where they are treated as before. A good sponge can be used many times, although ultimately it becomes hard and friable and must be discarded. Sponges saturated with pus or tuberculous material should not be used again.

Swabs.—For septic cases these have advantages over sponges in that large numbers can be prepared and thrown away when they have been used. They may be prepared either by cutting a roll of plain gauze into short lengths or from absorbent wool. A single layer of gauze about nine inches square is taken and upon the centre of it is placed a mass of wool, about the size of a small orange; the opposite corners of the gauze square are then tied together over the wool so as to enclose it completely and to diminish the risk of leaving fragments of wool behind in the wound. The swab should be quite soft and not tightly tied up. They may be sterilised either by boiling, by means of a high pressure autoclave, or by immersion in a 1 in 20 solution of carbolic acid for twenty-four hours. The ordinary steamer in which sterilisation is attempted at atmospheric pressure is not entirely satisfactory (*vide infra*). In most cases flat swabs are more useful than the round ones, especially if the latter be made firm and hard.

Dressings.—Although a large number of materials for dressings have been introduced, we are in the habit of using Lister's double cyanide gauze and salicylic or double cyanide wool almost exclusively. This gauze is impregnated with the double cyanide of mercury and zinc, a substance which, while it is almost insoluble in water, does dissolve slowly in albuminous fluids such as blood. As prepared commercially it is liable to contain a small quantity of free perchloride of mercury. Although the antiseptic contained within it is sufficient to inhibit the growth of organisms in fluids which it has absorbed, it is better not to trust to the sterility of this dressing as it is obtained from the manufacturers. An autoclave may be employed for sterilising this dressing, but as regards aseptic results we have found it no better than the method of sterilising the gauze by soaking it in an antiseptic solution. The dry dressing has advantages, however, from the point of view of the patient's comfort. External to the gauze we apply a mass of salicylic or double cyanide wool that has been sterilised in an autoclave.

The *apparatus for sterilising dressings* must be of necessity somewhat

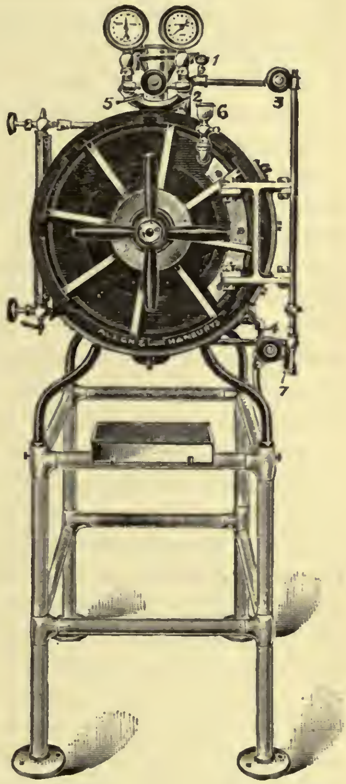


Fig. 24.—High Pressure Steam Steriliser.—This form of instrument is suitable for private work or a small hospital. The dressings, packed in suitable drums or boxes, are placed in the inner chamber. The water jacket is filled about three parts full, the level of the water being indicated by the gauge at the left-hand side of the instrument. A large gas burner is then lighted beneath the instrument, and when steam is escaping briskly the cock (2) is closed, the door of the inner chamber is tightly screwed up and the pressure in the outer chamber allowed to rise until the pressure gauge indicates 15 lb. to the sq. in. Cock (5) is then opened and steam allowed to pass into the inner chamber and expel the air, which is allowed to escape through cocks (1) and (6). When pure steam is issuing from these they are closed, and the communication between the inner and outer chambers cut off by closing cock (5). Cocks (3) and (4) are now opened so as to produce a partial vacuum in the inner chamber, the gauge for which is shown on the right-hand side of the instrument. Cocks (3) and (4) are now closed and steam is once more admitted to the inner chamber by opening cock (5). When sterilisation is complete, the vacuum appliance is once more brought into play, after communication between the two chambers has been shut off. Air is then admitted by opening a tap (6) which is in connection with a small metal cup containing sterilised wool to filter the air entering the sterilised chamber. The apparatus can be emptied by opening cock (7).

costly, and in consequence many so-called sterilisers have been introduced at a moderate price; but the efficiency of these is very doubtful. Inasmuch as the antiseptic requirements can be met amply by the employment of chemical antiseptics, which form a cheap and simple method of sterilisation, the use of dry sterilised dressings is not to be recommended unless a thoroughly efficient apparatus can be obtained. The apparatus which we use is shown in Fig. 24. It consists of an inner chamber, in which the dressings are placed, closed by a steel steam-proof door. This chamber is surrounded by a water jacket which can be heated by a powerful gas flame placed underneath. The flame of the gas burner is directed around the water jacket by an external casing lined with asbestos. The apparatus is fitted with appropriate pressure gauges, water gauge, and safety valve, and in addition there is a steam exhaust, by means of which a partial vacuum can be produced in the inner chamber.

The dressings or other articles to be sterilised are placed in the ordinary drums, which should be lined with lint or Gamgee tissue so as to prevent any dust finding its way into them between the time of sterilising and the application of the dressing. It is important to pack the dressings loosely so as to allow free permeation by the steam. After the drums have been placed within the steriliser, the perforations in their side being widely open, the steam door is closed and the gas burner lighted; when a sufficient head of steam has been raised, the air in the sterilising chamber is displaced by letting in the steam after opening one of the stop-cocks leading from this chamber. When pure steam is issuing, that is to say, when the lower portion of the jet in contact with the tap is invisible, the steam is shut off from the inner chamber and the exhaust connected. By this means a vacuum of eight to ten inches of mercury can be produced. This means that if steam were now admitted at atmospheric pressure to the dressing chamber it would permeate one-fourth to one-third of the bulk of the dressings. The sterilising chamber is now connected with the boiler, and steam is let in at a pressure of about twenty pounds to the square inch. The object of using steam at this pressure is twofold. In the first place, the pressure causes a thorough permeation of the dressings by the steam, leaving but little to the process of diffusion; the steam is forced two-thirds of the way into the dressings immediately, diffusion sufficing for the remaining third. In the second place, the temperature of steam at this pressure (260° F.) provides for the rapid destruction of all organisms and their spores. The dressings are left in the sterilising chamber for forty minutes; this is regarded by many as an excessive time, but it must be remembered that the actual time of sterilisation must be reckoned from the moment when the steam has penetrated the innermost recesses of the dressings, and therefore to ensure thorough sterility it is as well to allow a prolonged exposure to the steam. At the expiration of this time the cock connecting the boiler and the sterilising chamber is closed and the steam exhaust is brought into action for twenty minutes and by means of it the dressings are thoroughly dried. Towards the conclusion of this time the tap leading from the sterilising chamber to the outer air is open and air is sucked in through a mass of sterilised wool which effectually filters it. The dressings are now ready to be removed from the steriliser and may be used immediately or, if the tins have been carefully lined and the perforations in their side closed, can be stored until they are required. The salicylic wool loses a small amount of salicylic acid in this process but the amount is negligible; the double cyanide wool is unaltered.

If such an apparatus be not obtainable, all that is necessary is to place the gauze in a solution of perchloride of mercury, 1 in 2000, which is wrung out immediately before applying the dressing. We may here insist again that this method is in no way inferior to the more elaborate dry sterilisation except from the point of view of the patient's comfort, and is immeasurably superior to sterilisation conducted in inefficient apparatus.

THE DANGERS OF OPERATIONS AND THEIR PREVENTION.

The chief immediate risks of an operation are the dangers of the anæsthetic, the introduction of sepsis, loss of blood and shock; of somewhat less importance is the occurrence of syncope. The danger of anæsthetics is dealt with separately by Dr. Silk (see pp. 471 *et seq.*).

EXCLUSION OF MICRO-ORGANISMS.

Exclusion of micro-organisms is the really essential point in the treatment of wounds. Even if the steps necessary for the attainment of this object were to interfere with healing by first intention, it would still be incumbent on the surgeon to see that they were carried out, on account of the disastrous results that follow the entrance of micro-organisms into a wound. As a matter of fact, however, bacteria can be excluded without interfering with healing by first intention in any way. The exclusion of organisms during and after the performance of an operation is the essential Listerian principle, and this may be carried out in two ways. The one originally introduced by Lister, which has since undergone many modifications in details, consists in the preliminary disinfection of skin, hands, instruments, etc., in the use of antiseptic substances during the course of the operation, and in the subsequent application to the wound of dressings containing antiseptics. In the other method (sometimes termed the 'aseptic' method), the procedures are essentially the same in the preliminary stages, but the use of antiseptic substances during the course of the operation and afterwards in the dressings is avoided (see p. 153). There is no real antagonism between the two plans; it is merely a difference in the mode by which the same end is attained. In our opinion, the exclusion of micro-organisms is attained in practice much more certainly by the intelligent use of antiseptics than by the other plan.

Sources of Infection by Micro-Organisms.—Micro-organisms may enter a wound during an operation firstly from the skin in the neighbourhood of the wound itself; secondly, from the hands of the operator or his assistants; thirdly, from the instruments, ligatures, etc., that are used during the course of the operation; and fourthly, from the air. If the first three of these sources be properly guarded against, it will practically always be possible to obtain an aseptic wound. The organisms which fall in from the air are usually non-pathogenic, and will not grow in a wound the walls of which are brought properly into contact.

Disinfection of the Skin.—Micro-organisms are always present on the skin and are most numerous where it is moist, as, for example, in the axillæ, in the perineum, between the toes, and in the various folds of the skin. They are found not only in the old epithelium upon the surface, but also about the hairs, and they seem to penetrate to a certain distance into the hair follicles and sebaceous glands; hence their complete eradication is a matter of some difficulty. In order to get rid of them, antiseptic substances must be used, whichever of the two methods referred to above is to be employed.

We practise and strongly recommend the following method of disinfecting the skin: The skin should be shaved for a considerable distance round the area of the proposed operation. A lather of ether soap and 1 in 20 carbolic acid solution should be used. After shaving, the part is thoroughly washed with soap and 1 in 20 carbolic solution, or still better, a 1 in 20 watery solution of carbolic acid containing $\frac{1}{500}$th part of corrosive sublimate (this we have already referred to as the 'strong mixture'). This cleansing should be prolonged and thorough; the first washing should be done with the hands, and afterwards the skin should be scrubbed with a sterilised nail-brush and strong mixture. If possible, this purification should take place some hours before the operation, and a piece of gauze soaked in a 1 in 40 carbolic solution, but without any mackintosh outside it, should be fixed over the part so as to prolong the disinfection; in any case, the process should be repeated immediately before the operation. Before the incision is made, the strong mixture remaining on the surface of the skin should be washed away with a 1 in 2000 sublimate solution. It is always necessary to purify a wide area of the skin around the neighbourhood of the operation wound.

Precautions.—In children or those suffering from pyrexia (for example, hectic fever), it is advisable not to wrap the part up in a carbolic dressing after disinfection, as the drug is apt to be absorbed and may lead to dangerous symptoms of poisoning; in these cases the wet gauze or cloth which is afterwards put on to continue the disinfection should be soaked in a 1 in 2000 sublimate solution. The carbolic acid may be used for the disinfection of the skin immediately before the operation, but then little if any absorption will occur.

Various other methods of disinfecting the skin are employed, but none of them are as certain as the above. Mechanical cleansing of the skin with sterile water is quite inefficient. Alcohol is neither strong enough nor rapid enough in its action, and penetrates the epidermis badly; the best of the alcoholic solutions is 1 in 2000 biniodide solution in 70 per cent. methylated spirit. Painting the skin over with tincture of iodine has come into vogue lately, but it possesses no advantages over carbolic acid and is apt to leave the skin tender and easily irritated by the dressings, while it also leaves a quantity of old epithelium beneath which bacteria may spread into the wound after the operation.

Disinfection of the Hands.—Before using any disinfectant solution, the hands should be thoroughly washed, preferably in a running stream of hot water, the nails should be trimmed and all tags or scales of epithelium removed with scissors or pumice stone. A large number of experiments have been made to determine how far the hands can be disinfected by purely mechanical means, and the success which has followed some of these experiments has led to an exaggerated idea as to the efficacy of mechanical disinfection. It is no doubt possible to diminish very largely the number of micro-organisms by prolonged scrubbing with a sterile brush and soap under a running stream of hot sterilised water, but it cannot be insisted upon too strongly that the essential point in disinfection of the hands is the application of a chemical disinfectant, the 'scrubbing up' merely facilitating the action of the disinfectant by removing gross dirt. The skin of the hands of the surgeon and his assistants must therefore be disinfected in a manner exactly similar to that employed in the disinfection of the patient's skin (see p. 100). Although the use of india-rubber gloves has solved many difficulties in connection with disinfection of the hands, it does not allow any relaxation to be made in the stringency of the methods employed for sterilising the hands before the gloves are put on.

The method we employ is as follows: The patient is placed in the desired position on the operating table, the preparatory disinfection dressing is removed and mackintoshes are arranged around the field of operation. During these manipulations there is a risk of depositing infective material upon the skin of the patient or the hands of the surgeon and we therefore disinfect our hands and the patient's skin (see p. 100) afresh before the wet towels (see p. 102) are arranged around the field of operation. At this stage it is common to see the operator and his assistants wash their hands with ordinary soap and water. Any washing after the final disinfection of the patient's skin should be done with an antiseptic solution, the detergent powers of which are superior to that of water.

Gloves.—If gloves are to be worn, they should be put on at this stage. Gloves are best sterilised by half-filling them with hot water and boiling for half-an-hour. Before being drawn on the hands, they should be filled with a 1 in 4000 solution of perchloride of mercury. If the gloves be filled with the lotion, there should be no difficulty in putting them on rapidly. If they do not fit at the ends of the fingers they should be brushed upwards from the finger-tips towards the wrists with a nail brush until they are quite smooth. The surgeon should always wear gloves that fit perfectly and are somewhat on the stretch, as the diminution of tactile sensation is thereby reduced to a minimum. The assistants' gloves need be neither so thin nor so accurately fitting. Gloves with slightly roughened surfaces—the so-called 'never-slip' variety—are superior to smooth ones.

Precautions during the Course of an Operation.—Precautions must be taken to see that no infection of the instruments, sponges, etc., occurs during the course of the operation. The most essential of these precautions is to surround the area of the operation with aseptic towels wrung out of a hot antiseptic solution. If these *wet aseptic towels* be placed all around the area of operation, instruments laid down upon them do not become contaminated, and the same is the case if the hands of the operator or his assistants rest upon them. At the hospitals with which we are connected the towels are boiled and then put to soak for two or three hours before the time fixed for the operation in hot 1 in 2000 sublimate solution in a vessel with a tight-fitting lid or a hot-water jacket; they are then lightly wrung out and arranged around the field of operation. Towels prepared in this way are quite aseptic, and in private practice it is easy to instruct a nurse to do this. For operations of emergency, it will suffice to boil the towels and then wring them out of hot 1 in 2000 sublimate.

The clothes and blankets in contact with the patient must be covered with *mackintoshes* (the most convenient are those made of thin jaconet), and outside these, towels, prepared as just described, should be spread in all directions, so that nothing can by any chance be laid on septic objects, such as blankets, sheets, etc. During the operation also, the instruments should be handed to the surgeon direct from an antiseptic solution; although the small amount of carbolic acid which might enter the wound from the forceps, knives, etc., is not really injurious, it is well, in order to avoid unnecessary irritation, to rinse the instruments in a 1 in 2000 sublimate solution before using them; basins of this lotion should be beside the operator and his assistants during the operation, and after an instrument has been used, it should be rinsed in the sublimate solution before being used again.

A word of caution may be given concerning the manner of handing ligatures and sutures to the surgeon. It is too frequently the custom to seize the ligature by one end and hand it with the other hanging free. The consequence is that its free end is very likely to come into contact with some unpurified object, such as a blanket or an article of clothing, in transit, and sepsis may thus be introduced into the wound. All ligatures and sutures should either be given to the surgeon with the free end coiled up in the palm of the hand, or one end should be taken in each hand, and special care taken to see that the intervening portion does not touch any unpurified object.

Certain precautions as to *dress* must be taken by the surgeon and his assistants in order to avoid accidental contamination of the wound during the course of an operation. The sleeves should be rolled up well above the elbow, and a mackintosh apron reaching from the collar to the ground and furnished with sleeves reaching to the elbow should be worn. The outer surface of this apron is well sponged over with 1 in 20 carbolic lotion, and over it is fastened a bib sterilised by boiling and wrung out of 1 in 2000 sublimate solution. This is donned immediately before the operation is begun (see Fig. 25). This is better than the sterilised linen gown which is

FIG. 25.—OPERATING DRESS.—This consists of a mackintosh overall, to the front of which a boiled bib is buttoned. Rubber gloves are also shown. This apparatus can be prepared without a high-pressure steriliser, and is therefore suitable for operations in private houses where such an appliance is not available.

FIG. 26.—SURGEON WEARING OVERALL AND COMBINED CAP AND MASK.—This apparatus must be sterilised in a high pressure steriliser of the type shown in Fig. 24.

usually employed (see Fig. 26), because it keeps the surgeon's clothes from getting soiled, and because the antiseptic bib remains aseptic during the operation. Each assistant should take precautions similar to those employed by the surgeon, and should always wear sterilised rubber gloves whether the surgeon uses them or not. Caps and masks or veils are used by many surgeons as a matter of routine, but though advisable they are not absolutely necessary, unless the surgeon suffers from dandruff or sweats profusely, when he should wear a cap; or has a bad cough or cold, when he should wear a veil. It is well to remember that organisms may be projected from the operator's mouth into the wound during loud talking, and therefore all unnecessary conversation should be avoided during an operation and the voice tones kept at a low level. No surgeon who has any serious septic condition of the nose or throat should do an operation until he has recovered from it.

Management of Sponges.—The sponges, when removed from the jar in which they are kept, should be rinsed in a 1 in 2000 sublimate solution, and should never be washed in ordinary water during the course of the operation. When they have become soaked with blood, they should first be squeezed as dry as possible, then rinsed thoroughly in a cold 1 in 2000 sublimate, and placed in a basin containing a similar warm solution, out of which the surgeon wrings them before use. Every bowl, dish, or tray used during the operation should be sterilised outside and in, as there is always a chance of some part of it coming into contact with the hands, the instruments, the wound, or the field of operation. This may be done in an autoclave or by boiling. Failing either of these methods, they should be immersed for an hour or more in a 1 in 20 carbolic solution, or, failing that, scrubbed thoroughly with it. The nurse should of course disinfect her hands; but, as she is constantly soiling them, she should not be allowed to wring out and hand the sponges; if she does, she must disinfect her hands scrupulously and must be told off exclusively to hand sponges. This is an important point which is constantly neglected.

Avoidance of Aërial Infection.—At one time considerable stress was laid upon the chance of wound infection by the air, but we now know that the organisms generally met with in the air are saprophytes, which do not grow in the tissues; in fact, they are non-parasitic organisms. Hence the risk from organisms falling into the wound from the air, and giving rise to trouble, is comparatively slight. At the same time it must be admitted that, in a hospital ward where a case of erysipelas may be present, there would be such a risk, and in hospital practice there must always be a certain degree of danger from this source.

When instruments, sponges, etc., are always immersed in antiseptic solutions any aërial organisms which come into contact with them are rendered inert, for though spore-bearing organisms may not be destroyed, the non-spore-bearing forms such as those of erysipelas are killed at once.

HÆMORRHAGE AND THE MEANS OF ARRESTING IT.

Bleeding may be arterial, venous, or capillary in nature. In arterial bleeding, blood of a bright red colour spurts from the cut vessel synchronously with the systole of the heart, and flows continuously during the diastole. In venous bleeding there is a steady flow of dark blood, except in the case of the veins of the neck, where it escapes in jets at each expiration, with a steady flow between. Capillary bleeding is an oozing from the surface of the wound.

Spontaneous Arrest of Bleeding.—Bleeding from any of these sources may cease spontaneously, failing which, special means will be necessary to arrest it. The mode in which hæmorrhage ceases spontaneously differs according to the blood-vessels concerned in the bleeding. In the case of arteries divided transversely, the circular fibres of the muscular coat contract so that the orifice of the vessel is narrowed; at the same time the internal and middle coats curl up in the interior of the vessel, and the longitudinal fibres contract and shorten it, so that it retracts within its sheath. These changes are followed by clotting of the blood; as soon as the blood comes in contact with tissues which are injured, or which are not similar to the healthy lining membrane of the vessels, it undergoes coagulation. Consequently, clotting tends to take place as soon as the blood escapes from the vessel, unless the flow of blood be so free that the clot is swept away by it. In the case of small vessels, clotting occurs where the blood comes in contact with the divided coats, more especially between the vessel and its sheath, and the clot formed there tends to occlude the ends of the artery still further by its pressure. This clot forms a mechanical obstacle to the escape of the blood (provided that the force of the blood stream be not sufficient to expel it), and it soon extends upwards into the interior of the vessel, in most cases as far as the nearest collateral branch. The result is that a conical wedge of blood-clot is formed inside the vessel, which is very effectual in bringing about cessation of the bleeding.

The endothelial cells then begin to multiply in the neighbourhood of the clot which they rapidly cover. Losing their typical flattened shape they grow into the substance of the clot, and from them is formed a large amount of the connective tissue which replaces the thrombus. At the same time connective tissue grows in from the neighbouring parts, so that the divided end of the vessel becomes completely occluded by fibrous tissue and shrinks up. Ultimately a small fibrous cord is all that remains to represent the vessel from the seat of division to the nearest collateral branch. When an artery is only partially cut across, the contraction and retraction of its coats tend to enlarge the orifice, and so to increase bleeding rather than diminish it, and in these cases the natural hæmostatic process cannot occur until the vessel has been completely divided.

Capillary bleeding ceases simply as the result of coagulation of blood in the capillaries. Venous bleeding ceases as the result of the formation of a small clot outside the vein and the subsequent sealing of the part with lymph when the vein is only partially divided; when the division is complete, clotting occurs and the vein becomes closed by adhesion.

It does not necessarily follow that a clot will form in the interior of a vein if the latter be only partially divided.

Means of controlling Hæmorrhage.—When a large artery has been divided or when a small one has only been partially cut across, the bleeding will not stop spontaneously, and some artificial means must be adopted to arrest it. Capillary bleeding, on the other hand, is only troublesome in cases of hæmophilia, where coagulation of the blood does not take place properly, and very persistent oozing may occur. Bleeding from a partially divided vein usually ceases spontaneously, except when severe coughing or crying gives rise to an obstruction to the flow of blood through the veins, and leads to expulsion of blood through the divided wall.

Tourniquets.—It is necessary to consider not only the arrest, but also the prevention of hæmorrhage. Under certain circumstances it is advisable to arrest the circulation in the part upon which an operation

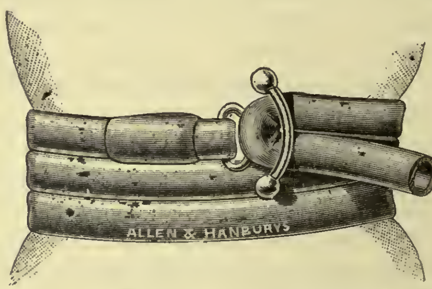


Fig. 27.—Esmarch's Rubber Tourniquet.—The appliance which consists of a length of rubber tubing is tightly wound two or three times round the limb and secured by the anchor catch in the method shown.

is being performed. Formerly this was done by means of a tourniquet, a band tied tightly round the limb, furnished with a screw and a pad which was placed over the artery, and screwed up until the circulation through the vessel was arrested.

Esmarch's Bandage.—The chief disadvantage of the old tourniquet is that, while it arrests the flow of blood through the main vessel, it does not control the collateral circulation. At the present time a rubber band, with which the name of Esmarch is associated, is wound firmly round the upper part of the limb and in this way the entire circulation through the limb is effectually controlled. In amputations in weakly patients it is also of importance to preserve the blood which is already present in the limb. Esmarch's plan is to bandage the limb spirally from the extremity upwards with a broad elastic bandage applied very firmly, so as to expel all the blood from the vessels; when the upper part of the limb is reached, a rubber tube or cord is applied transversely around it, and, when this has been fastened, the spiral elastic bandage is taken off. This method is both unnecessary and frequently undesirable. It is very undesirable in cases of tumours or of suppuration, as in them the elastic bandage is apt to squeeze pus or tumour substance into the tissues or vessels during its application, and thus serious results may be caused.

Lister's Method.—On the other hand, the plan introduced by Lord Lister, of elevating the limb for a few minutes before applying the elastic tourniquet, suffices to empty the limb of blood. If the limb be elevated, the veins collapse immediately, and the main arteries contract reflexly, so that the limb becomes practically bloodless if the elevated position be maintained for two or three minutes. When this has been done and while the limb is still raised, india-rubber tubing is wound firmly around its upper part. In this way, it is easy to obtain a field of operation as free from blood as by Esmarch's method without any risk of disseminating pus or tumour substance.

It is only in a few cases that this bloodless plan is of real advantage. It is of great value in operations such as suture of nerves or tendons, where delicate dissection would be marred by the presence of blood in the wound. In amputations, too, it is valuable, as the main vessel and its larger branches can be tied before the blood is allowed to flow through the vessels again. It is also useful in operations for necrosis, as it allows the surgeon to distinguish easily between the living and the dead structures ; but it is not so good in cases of tuberculous joints, where the accurate recognition of the diseased tissues depends to a considerable extent on the vascularity of the part.

Objections to 'Bloodless Methods.'—There is one great general objection to the use of Esmarch's bandage and the principle of bloodless operations generally. It is that, if the operation be a prolonged one, the after-bleeding is very severe, and the amount of blood lost by the patient is probably as great when the bandage is used as when it is not. Moreover, a longer time is spent over the operation, because an unduly large number of vessels must be tied, and it is not wise to sew up the wound until the oozing has stopped. When the bandage is removed, the vessels dilate, the limb flushes and becomes redder than its fellow, and there is a certain amount of vaso-motor paralysis, in consequence of which many vessels go on bleeding, and require ligature ; had the bandage not been used, this bleeding would have stopped almost immediately. Blood may also collect in the wound after it has been sutured, and interfere with union.

Ligature.—*Temporary.*—In some cases hæmorrhage is prevented by occluding the main vessels supplying the part either by means of a permanent ligature or by the application of a temporary ligature, digital compression, or Crile's clamps. In applying a temporary ligature care must be taken to injure the vessel as little as possible ; the ligature should be broad ; a piece of tape, a kangaroo tendon or a thin rubber band answer very well. It is best not to tie these temporary ligatures ; it is sufficient to make gentle traction upon the ends of the loop around the vessel and thus draw it up to the surface. This produces a partial kink which is sufficient to check the flow of blood.

Permanent.—When bleeding does not cease spontaneously soon after division of an artery, it is well to apply a ligature to the vessel. The effect of this is to divide the internal and middle coats, which curl up in the interior of the vessel, and also to constrict the external coat firmly, so as to prevent the escape of blood. The materials used for ligatures may be absorbable or non-absorbable, or absorbable only with great difficulty. The best of the absorbable materials is *catgut*, which has been already dealt with fully in connection with suture materials; its mode of preparation will be found on p. 93. Catgut prepared according to Lord Lister's recommendations is a most satisfactory ligature material.

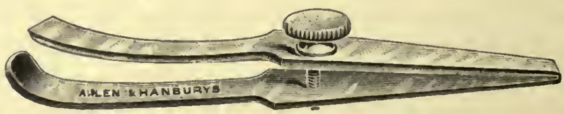
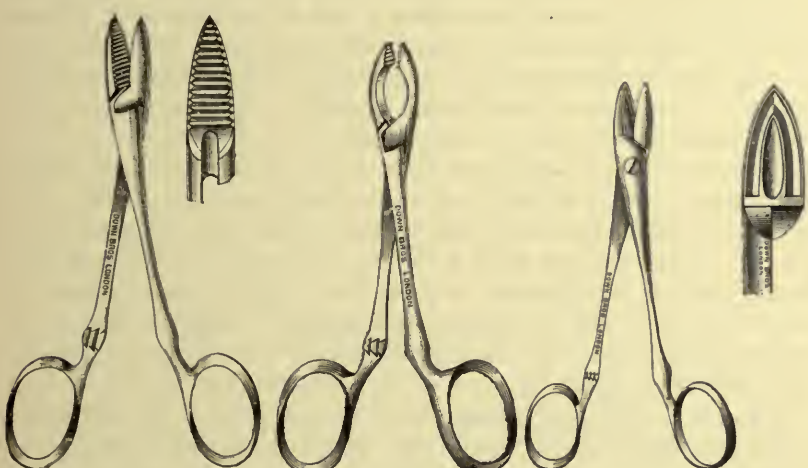


Fig. 28.—Crile's Clamps for Temporary Hæmostasis.—The blades should be sheathed in rubber tubing.

Cautery.—In parts where ligatures cannot be applied, *e.g.* the bladder, the bleeding may be arrested by means of the cautery, the most convenient form being Paquelin's. It must not be used white-hot, as in that case it will cut through the vessel, and bleeding will persist; it should be allowed to cool until it is hardly red. When a hot point like this is held in contact with a vessel, it sears the tissues so that they stick together, and clotting occurs inside the artery.

Torsion.—Another way in which arterial bleeding may be arrested is by torsion. The object of torsion is to twist the end of the artery so that the middle and internal coats are ruptured and curl up, while the twisted external coat forms an obstacle to the escape of blood. In order to do this, the artery must be fixed above the point at which the coats are to be ruptured, as otherwise, in a large artery at any rate, the only effect would be to twist the artery round and round in its sheath for a great distance without attaining the desired result. A large artery, therefore, should be pulled out of its sheath and grasped with a pair of forceps transversely to its long axis above the point at which the torsion is to be employed; the cut end of the artery is then grasped with another pair of forceps, and twisted until the coats are felt to give way. Four complete revolutions are generally enough. It suffices to get a small artery as free from the surrounding tissues as possible, to grasp the tissues above it firmly with the fingers of one hand, and then twist up the part seized by the forceps with the other hand. Although torsion answers very well in many cases, we cannot recommend it as a satisfactory substitute for ligature. It was introduced before the aseptic period, when ligatures had to separate, and when, therefore, there was a danger of secondary hæmorrhage; now that ligatures are cut short and never separate from the divided ends of the artery, there is no risk of secondary hæmorrhage, and torsion is rarely used except for small vessels. It is, however, very useful for them in certain cases, such as those in which there is a certainty or a probability of the wound becoming septic. Here the absence of ligatures from the wound may allow much earlier healing than would otherwise occur. It is also useful for superficial vessels such as those of the skin. If these be ligatured, the ends of the ligatures are apt to project between the lips of the wound.



A B C

FIG. 29.—PRESSURE FORCEPS FOR ARREST OF HÆMORRHAGE.—The above are the varieties in common use. A, *Lawson Tait's*, very similar to Spencer Wells's, but tapered at the points so as to facilitate the application of a ligature; this is still further facilitated in the pattern B, which is useful in tying vessels at the bottom of a deep wound. C, *Greig Smith's*; these forceps are designed to crush the walls of a vessel firmly together, and at the same time to cut through their inner and middle coats. The full-size illustration of the blade shows how this is done.

Pressure.—Pressure is also a very important method of arresting hæmorrhage, especially of the venous or capillary variety; venous bleeding can be readily arrested by it, and in many cases in which it is undesirable to have ligatures on the surface of the wound, as for instance, in operations about the lips, the surgeon makes use of pressure to arrest the hæmorrhage. The pressure stops the flow of blood through the vessel while a clot is being formed. A method of employing pressure that has enjoyed a considerable vogue is by means of the '*graduated compress.*' When the bleeding point is deeply seated, and it is not desired to open up the wound, pressure may be employed to arrest the hæmorrhage. If, however, the pressure be applied in the form of a simple pad over the surface of the wound, the bleeding may go on in the interior; a good example is bleeding from the socket of a tooth after the latter has been extracted. Cases of this kind require the application of a graduated compress; a tiny piece of gauze or lint is placed on the bleeding point, then pieces are added, gradually increasing in size until a conical pad is formed, the outer part of which projects well above the surface. Then pressure is applied through the cone actually on to the bleeding point by means of a bandage, or, in the case of a tooth, by fixing the two jaws together.

Temporary Pressure by Forceps.—The hæmorrhage from small vessels can often be arrested by pinching them tightly in strong forceps, such as Spencer Wells's, or, perhaps even better, those devised by Greig Smith (see Fig. 29). If the various bleeding points be compressed in this way as the operation proceeds and the forceps be left on, it will be found that, by the time the operation is completed and the forceps are removed, few of the vessels bleed and require ligature. Thus, a great deal of time is saved in the course of a long operation.

In severe and protracted operations such, for example, as amputation of the breast, it is very important to examine the whole of the wound for bleeding points just before the sutures are inserted. In these operations the blood pressure often falls very low while the axilla is being cleared out and many vessels stop bleeding only to bleed again as the patient recovers. Again, when an operation has been conducted in the Trendelenburg position, it is important to lower the patient to the horizontal before commencing to close the wound. Unless this be done, vessels may commence bleeding which had stopped while the patient was in the inverted position, and serious hæmorrhage may result.

Horsley's Wax.—Sir Victor Horsley has introduced an aseptic wax for use in bleeding from bone, which can be applied over the bleeding point, so as to close the hole in the bone from which the blood comes. The composition of this wax is: Beeswax, 7 parts; almond oil, 1 part; and salicylic acid, 1 part. When not in use, the wax is kept in a vessel of 1 in 20 carbolic solution. When it is required for use, a small piece is pinched off, softened by rolling it between the fingers, which, of course, should be aseptic, and then pressed well into the part of the bone from which the blood is coming. The wax does not give rise to any trouble in the healing of the wound.

Cold.—There are various other ways in which bleeding may be arrested, and which are specially applicable to oozing from small vessels or capillaries which cannot be controlled by the means already mentioned. The chief of these are those methods that bring about contraction of the coats of the vessel, especially cold. The application of cold to the skin over a bleeding part will lead to contraction of the cutaneous vessels, and reflexly to contraction of those of the deeper parts. For example, in operations about the mouth or lips, such as those for cleft palate or hare-lip, bleeding can often be quickly arrested by douching the face with iced water, or should that fail, by the application of ice to the neighbourhood of the bleeding part.

Leiter's tubes, which have already been mentioned in connection with inflammation (see p. 10), are very effectual in checking bleeding. For example, in hæmorrhage from the urethral mucous membrane, due to injury or gonorrhœa, a very efficient plan is to coil Leiter's tubes around the penis, and pass a stream of ice-cold water through them. The effect of the cold is to make the penis contract, and therefore it is well to pass a straight catheter a short distance up the urethra before fixing on the coil. The result of applying cold in this manner is that contraction of the cutaneous vessels occurs followed by contraction of the deeper-seated ones, and if this be kept up for a short time coagulation and permanent occlusion of the bleeding vessels will follow. The precautions to be observed in using these coils are mentioned on p. 10.

Heat.—Heat is almost equally efficacious in arresting bleeding, and douching the bleeding part with hot water has a powerful hæmostatic effect. The temperature of the water should range between 110° and 120° F., and the condition for which it is chiefly employed is post-partum hæmorrhage, the uterus being flooded with water at this temperature.

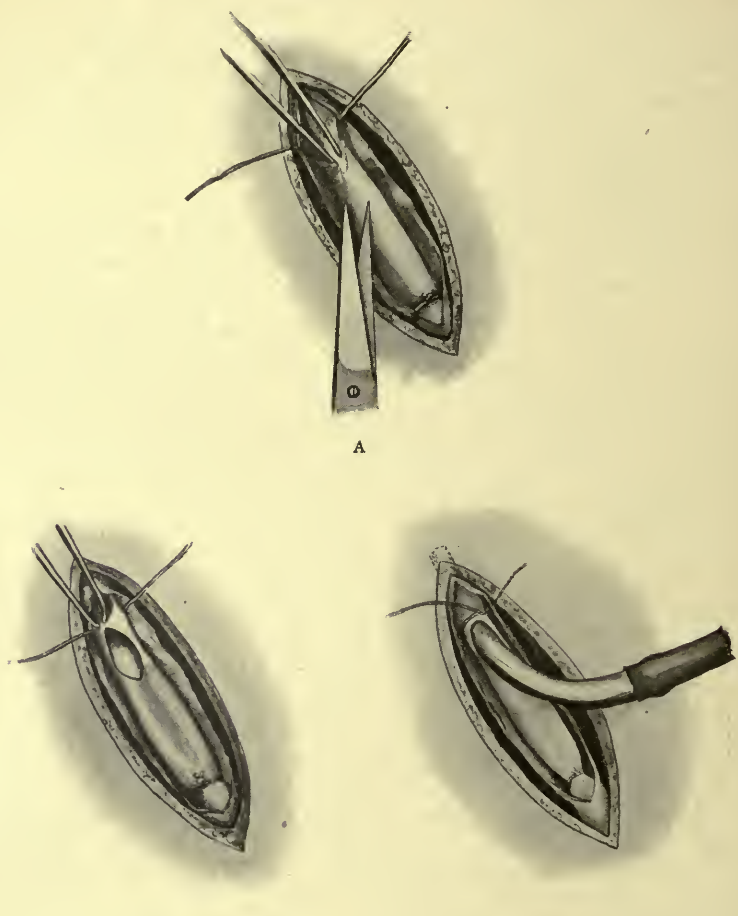
Styptics.—Hæmorrhage may also be arrested by producing coagulation of the blood as it escapes from the vessel by means of styptics. It is useless to pour the styptic solution into a bleeding wound or to swab one over with it. The bleeding must first be temporarily arrested, because the clot produced by the styptic must form actually in the orifice of the bleeding vessel and not on the surface of the wound if the method is to be effectual. The bleeding area should be compressed in some suitable manner, so that the bleeding is temporarily arrested; it is then painted over with the styptic solution, and the pressure is maintained for a short time in order to keep the wound from bleeding, and to give the styptic time to act. The styptics usually employed are the liquor ferri perchlor. B.P., the liquor ferri perchlor. fort. mixed with an equal part of glycerine, or tincture of matico. Perchloride of iron is a powerful styptic, but it often causes a slough on the surface of the wound, which is a source of danger in the mouth or in any part where sepsis subsequently occurs, as septic micro-organisms are likely to grow in it. Adrenalin chloride (1 in 1000) is not open to this serious objection, and is a very efficient styptic when the hæmorrhage comes from small arteries. It is not of use in bleeding from veins; for example, it is useless in cases of hæmorrhage from the venous channels of the diploë. Lactate of calcium has been employed recently in the treatment of hæmorrhage, more especially as a prophylactic before an operation in which severe hæmorrhage is likely to be encountered, or when the coagulability of the blood is imperfect. It should be given for several days before the operation in doses of five to ten grains three times a day, or in single doses of thirty to sixty grains given by the rectum some hours before the operation. Opinions are divided as to its merits.

Symptoms of Serious Loss of Blood.—So much blood may be lost, either from continuous oozing from the vessels, or from its sudden escape from some large trunk, that the patient's life is endangered. Bleeding may also occur under a dressing, or into the abdomen in cases of abdominal operations, after the patient has been removed to bed, and it is necessary that the surgeon should recognise the symptoms of serious loss of blood. They are pallor, a rapid, soft, and feeble pulse, gasping or sighing respiration from imperfect oxygenation of the tissues, and a tendency to twitching of the muscles; when the hæmorrhage is rapid the patient soon loses consciousness. The most typical sign is restlessness; the patient gasps for air, throws himself about, and uncovers his chest in the endeavour to get more air into his lungs.

Transfusion and Infusion.—These symptoms should at once lead the surgeon to assume that serious bleeding is going on, and the dressing should therefore be removed immediately, and the wound opened up if necessary, with the view of securing the bleeding point. The patient's condition may be so bad that it is not advisable to search for the bleeding point, lest he die during the attempt to find it, and in such a case, temporary pressure must be resorted to. In any case, measures must be taken to restore the volume of fluid in the blood-vessels by means of infusion if the loss of blood be serious. The fluid used for infusion may either be blood, pure, mixed with phosphate of soda, or defibrinated—in which case the operation is termed transfusion; or an indifferent fluid, such as normal saline solution—when it should be called infusion. The use of blood, either pure or mixed with phosphate of soda, has been found unsatisfactory, since the red blood corpuscles introduced have comparatively little effect as carriers of oxygen, and there is great difficulty and risk in introducing pure blood, chiefly owing to the formation of coagula in the instruments, or the detachment of coagula from them giving rise to pulmonary embolism. Even defibrinated blood is not free from this last objection. On the other hand, indifferent fluids answer the purpose of giving the heart enough fluid to contract upon, and enabling it to drive what corpuscles remain through the circulation, thus keeping the patient alive until fresh blood has been manufactured, without exposing him to the risks of the other method. We shall not describe the technique of transfusion with blood.

Saline Infusion.—The most common material for infusion is the ordinary *salt solution* used in physiological work, that is to say, a 0·75 per cent. solution of common salt. In practice, this is roughly about a teaspoonful of common salt to the pint of water. The solution should be boiled and allowed to cool down to 100° F. by standing it under cover or in ice. In cases of emergency, however, it is not always easy to get boiled water, and too much time is wasted if the water has to be boiled and cooled, and therefore it is necessary to risk the introduction of organisms by mixing the water from the kitchen boiler with sufficient ice or cold water to reduce the temperature to the required degree. It is a common practice to mix ordinary table salt with sterilised water in the proper proportions and to look upon this as sterilised saline solution. The salt is more likely to contain organisms than is tap water and must always be sterilised by boiling before use. Even in cases of emergency it is possible to boil the required amount of salt in a small quantity of water and then dilute it as above.

In introducing the saline solution a vein is exposed (preferably the median basilic), a double ligature of cagut is passed around it, the loop divided in the centre, and the two threads separated from one another. An oblique cut is then made through about half the calibre of the vessel between the two threads, and the nozzle of a suitable canula is inserted into the opening and tied in by the upper of the two threads of the double ligature, the vein also being ligatured below by the lower thread, so that the blood does not escape from the distal end (see Fig. 30). There may be difficulty in making the vein prominent when the circulation is feeble. If it cannot be seen by lightly constricting the upper arm, the best plan is to make a transverse cut across the direction of the vessel down to the deep fascia ; the divided ends of the vein can then be seen, the distal end ligatured, the proximal grasped with forceps, and the canula introduced and tied in. Before the canula is inserted, a piece of india-rubber tubing is attached to it, and to the other end of this is fitted a sterilised glass funnel or the barrel of a glass syringe from which the piston has been removed. The whole of this apparatus must be sterilised by boiling previous to use, filled completely with salt solution so as to expel all the air, and clamped with a suitable clip. Care must be taken that no air gets in at any time. The funnel is held from two to three feet above the level of the patient, the clamp is opened, and the fluid allowed to flow gradually into the vein, care being taken to see that the funnel is replenished before the fluid in it has quite run away, as otherwise air may find access to the tube and so to the circulation. The rapidity of the flow can be regulated by raising the funnel above the level of the heart; this can be done better by means of a funnel than if the saline solution were injected by means of a syringe. The amount of fluid introduced should be from two to five pints, and the condition of the patient has to be carefully watched during its introduction. If it enter too rapidly, the fluid that is driven from the heart into the lungs may consist of pure salt solution, and consequently signs of imperfect aëration of the blood become evident; the respiration becomes embarrassed, and twitchings and restless movements occur, and the patient may die at once. If these symptoms occur, the tube should be clamped and the further introduction of fluid deferred until the dangerous symptoms have passed off. About half-an-hour should be taken to introduce two pints of the fluid, and it is well to stop occasionally to allow the blood to be mixed thoroughly with the saline solution. The original source of bleeding must be controlled in all cases either by



A

B C

FIG. 30.—INTRA-VENOUS INFUSION.—(A) The vein has been exposed and its sheath opened; two ligatures have been passed beneath it, the distal one of which has been tied, the upper one being left around the vein at the opposite extremity of the wound. The wall of the vein has been pinched up with a pair of fine forceps and a V-shaped incision is about to be made into the wall of the vein with a pair of scissors. (B) The incision has been made, the forceps retaining their original hold upon the wall of the vein, which has been lifted up so as to expose and stretch the opening. (C) A canula has been passed into the opening in the vein and along its lumen for a short distance, its position beneath the skin at the upper end of the wound being indicated by the dotted lines. The second ligature has been tied in a single knot around the canula and is ready to occlude the vein when the canula is withdrawn.

ligature or pressure, otherwise the rise in blood pressure following the infusion may start a fresh and fatal hæmorrhage. It may be necessary to repeat the infusion in an hour or so when much blood has been lost.

Unless there be also great shock, however, one infusion is usually sufficient to tide the patient over until a sufficient quantity of fresh corpuscles has been manufactured.

When the condition is less urgent, it is better to allow the fluid to be absorbed rather than to inject it directly into the circulation, and this may be done by injecting the salt solution either into the rectum or under the mamma. In the latter case from fifteen to twenty ounces can be introduced on each side. Absorption will be then so regulated by the body that too rapid dilution of the blood will not take place.

An excellent plan, especially when there has also been shock, is to introduce the salt solution very slowly into the rectum. An irrigator preferably surrounded by a hot-water jacket is filled with salt solution at

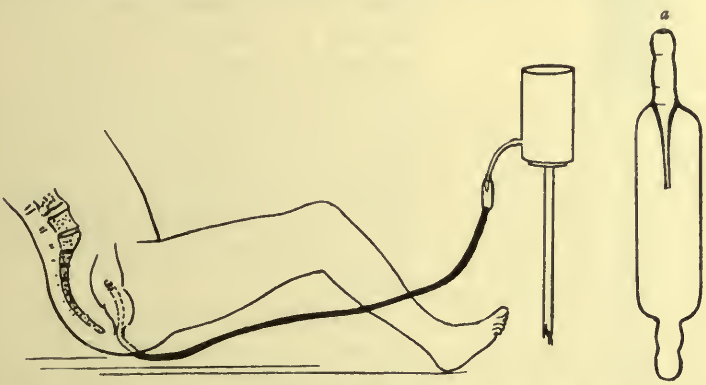


Fig. 31.—Diagram to Illustrate the Method of Continuous Rectal Infusion.—The reservoir is shown supported upon a stand slightly raised above the patient's pelvis, it is connected by a length of rubber tubing with a rectal tube made of some unyielding material or of stout india-rubber. The rate of flow can be seen by the aid of the glass dropping tube (*a*) shown on the right of the apparatus.

110° F. and fixed from six to twelve inches above the level of the anus, the outflow through the tube being regulated so that the fluid only comes out drop by drop, about a pint an hour. The tube from the irrigator is attached to a rubber catheter introduced well into the rectum and left there. The advantage of this plan is that every drop of the fluid is absorbed and there is no distension of the bowel which would lead to expulsion or escape of the solution, while the administration may be continued for hours.

Many variations of this method have been introduced. In one form the saline solution is kept at a constant temperature by means of a 'Thermos' flask; in another by an electrical device. In the latter apparatus the receiver is filled with salt solution at a temperature slightly above that of the body and a connection made with the house current. The heating device is so arranged that the temperature at which the saline leaves the container remains constant. It must be remembered, however, that a considerable amount of heat is lost in the passage of the fluid through the pipe which leads into the rectum, and it is always safer to conduct a few experiments with the apparatus and the exact length of tubing to be employed before actually using it.

If no such apparatus be at hand, an ordinary douche can may be employed. This should be provided with a long delivery tube, which is coiled in a pail of hot water, before it is led into the bowel. The irrigator is filled with warm saline solution, which is kept hot in the tube by the water in the pail. The temperature of the water in the pail is kept up by repeated additions of boiling water. It should be as hot as the hand can comfortably bear. In another form of apparatus the slow absorption of the saline solution is obtained by keeping the surface of the fluid in the irrigator a very short distance (two or three inches) above the rectum. The rate of flow can be regulated by raising or lowering the irrigator. In this form of apparatus the delivery tube should be as short and as wide as possible so as to permit the passage of flatus.

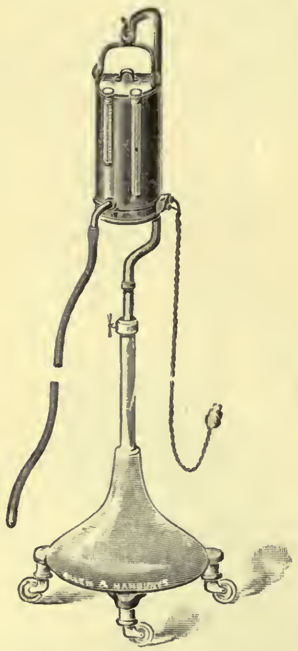


Fig. 32. — Electrical Apparatus for maintaining the temperature of saline solution for continuous rectal infusion.

In all these forms of apparatus care is necessary to see that the flow is not impeded by kinking of or pressure upon the tube into the rectum. Two simple devices to obviate this inconvenience are: to employ flexible gas-tubing at the vulnerable points, or to lead the rubber-tubing through fibre-tubing of suitable size; both withstand pressure well.

After an operation blood may be found oozing through the dressing. If this be not excessive, the bandage should be moistened with 1 in 20 carbolic solution and some wet gauze applied outside. If, however, the oozing continue and the wound become increasingly painful, or if the patient show signs of severe loss of blood, the dressing must be removed and the condition of affairs investigated. It will often happen on exposing the wound that no bleeding can be seen coming from between its margins or through the drainage tube, if one has been used; should this be the case, the wound should simply be re-dressed. The explanation is that the blood which was poured out during the first few hours after the operation has percolated through the dressing and given the false impression of a continuous hæmorrhage. If it be obvious, however, that hæmorrhage is still going on, some at least of the stitches must be undone. It will very often be found that the hæmorrhage is coming from a superficial vessel in the skin itself and, as in these cases the blood escapes through the part of the wound nearest to the bleeding vessel, it is often only necessary to take out one or two stitches. If, however, the whole wound be distended with blood-clot, it is better to give an anæsthetic, open it up, and clear out the clots. This procedure alone often suffices to check the hæmorrhage. If a bleeding point be found it must be ligatured; if the hæmorrhage be obviously due to general oozing, the wound should be carefully packed with gauze and a firm bandage applied.

It is very important to act with due deliberation and with full antiseptic precautions in these cases. Although the case is urgent, the few minutes necessary for sterilising instruments, etc., is rarely of much moment, while any omission to do this may lead to grave sepsis.

SHOCK.

There are several factors in the complex of symptoms known as shock, and this must be borne in mind in dealing with patients who are subjected to a surgical operation. In the first place there is the simple reflex cardiac inhibition seen when a patient faints as the result of a blow. This is often seen in the course of a surgical operation involving traction or pressure upon large nerves. The patient becomes pale, has an almost imperceptible pulse, while the breathing is rapid and shallow and the whole muscular system toneless and flaccid; sweating is often observed in addition. This condition usually passes off fairly rapidly, but if the stimulus be prolonged, the condition may become more serious, and may be an important contributory factor in bringing about an immediately fatal result.

Death occurs partly from the severity of the shock (the nerve centres being unable to regain their power) and partly from its duration. When the depression is long continued, and the circulation consequently extremely feeble, clots are apt to form in the pulmonary artery, and recovery is then out of the question. In addition to the cardiac inhibition there is a lowering of the blood pressure. There has been much controversy as to the pathology of this condition, but the balance of evidence points to its being due to general dilatation of the peripheral vessels. Post-mortem observations are of little value, inasmuch as after death the arteries are always found practically empty. The fall of blood pressure is accentuated by actual loss of blood from hæmorrhage and possibly, according to some experimenters, to inspissation of the blood itself.

Shock also has an effect upon the higher cerebral centres, shown by the prolonged effect of severe operations upon the nervous stability. It is a matter of common observation that after operations, especially upon the sexual organs, the patient will often exhibit unwonted emotional phenomena long after the operation. For example, a woman will often be abnormally irritable or at times hysterical for twelve months after a hysterectomy, although recovery from the operation seems to have been complete. Even after less severe operations the condition of mental lassitude and irritability is often well marked, and patients will be content to lie in bed doing nothing when they might be expected to read, write, or otherwise amuse themselves.

The effect of the anæsthetic must be also borne in mind. All anæsthetics are protoplasmic poisons, and in some cases microscopical changes can be actually observed in the tissues after prolonged anæsthesia, for example, fatty degeneration of the liver cells and disappearance of the Nissl granules of the cerebral cortex. Moreover, during anæsthesia the loss of heat from the skin is not compensated for by the action of the thermal centres and the patient is therefore extremely sensitive to cold. Under normal conditions, lowering of the temperature leads to an increase in the output of carbonic acid, but in an anæsthetised condition the reverse obtains and the carbonic acid output is actually diminished as the temperature falls. This point, which has been investigated experimentally, indicates the importance of warmth during the administration of an anæsthetic. The degree of shock depends on the part of the body operated upon ; for example, a long time may be spent in repairing a badly united or un-united fracture of the extremities without producing anything like the amount of shock that a much shorter and gentler operation on the abdominal cavity will cause, especially if the peritoneum be inflamed. Loss of blood also increases the risk of shock, which is therefore more marked in operations in which there is severe hæmorrhage.

SYMPTOMS.—If shock comes on during an operation, its presence is indicated by increasing pallor and weakness of the pulse, which becomes rapid, dicrotic, and sometimes irregular. The pupils become dilated, the reflexes are slow, there is often sweating about the forehead, and the skin becomes cold. After the operation the pulse remains bad and the patient cold, and, though consciousness may be recovered to some extent, the senses are dull. When severe shock is established it is difficult to overcome, and therefore it is very important to take measures beforehand to avoid or diminish it as much as possible.

TREATMENT.—(*a*) **Prophylaxis.**—We have already referred to several points in the preparation of the patient which are important in connection with the question of shock, such as his frame of mind, a good night's rest previous to operation, and the administration of food ; of special importance is a *nutrient enema* half-an-hour before the hour fixed for the operation.

An essential precautionary point is to *keep up the body temperature.* The temperature of the operation room should be maintained at 65° to 85° F. This, however, is not of itself sufficient in bad cases, and the best plan is to have the table on which the patient is lying kept at 100° to 105° F. by means of hot water. In some operating tables this is accomplished by having the top of the table composed of a series of tubes through which hot water circulates, but this necessitates a special table. An equally good plan is to have a large copper tray about six inches deep and five feet in length, with a metal top, and tubes at the ends for the entrance and exit of hot water, which is kept circulating through it during the operation. Where this is not available, its place may be supplied by a water-bed or large water-pillow filled with water at a temperature of 110° F. The latter is frequently used in operations upon children, although it is not so steady as the hot-water table. Whenever there is any chance of the flannel covering the hot-water bottle or pillow becoming wet during the operation, mackintosh should be interposed between this and the patient's skin ; otherwise the wet flannel will scald the patient. This is not uncommon in operations upon small children lying upon india-rubber hot-water bags. Hot-water bottles are, however, always dangerous and should never be used when it is possible to keep the patient's temperature up in any other way.

The table should be covered with warm blankets, on which the patient lies, and the aseptic towels around the area of operation (see Chap. V.) are wrung out of hot lotion and changed at intervals. When the arrangements above described are not available, the room should be kept as warm as one can work in. All lotions used during the operation should be at about a temperature of 100° F. If coils of intestine escape in abdominal operations they should be replaced at once, or should be covered with warm aseptic cloths or sponges frequently renewed, if it be necessary to keep them outside the body. In infants, an incision large enough to admit only two fingers is relatively extensive compared with the size of the abdomen and it often happens that a sudden straining movement will eject practically the whole of the small intestines. These can be satisfactorily protected from injury and kept warm by allowing a constant stream of hot saline solution to run over them either from an irrigator or poured out of a jug.

Rapidity of operation is also important in cases in which shock is likely to occur. The steps of the operation should be carefully planned beforehand, and all necessary preparations made before the anæsthetic is administered, so that no time is lost afterwards. When it is important to reduce the time that the patient is under the anæsthetic to a minimum, all preliminaries, such as shaving, purification of the skin, arrangement of aseptic towels, etc., should be carried out before the anæsthetic is commenced. Loss of blood should also be avoided as far as possible. The management of the anæsthetic has been specially referred to in the section dealing with Anæsthetics.

The administration of *strychnine* before the commencement of the operation is of great value in the prevention or diminution of shock. In an adult, a thirtieth of a grain should be injected subcutaneously just before the operation, or while the patient is being placed under the anæsthetic; this may be repeated more than once during the operation, if the pulse begins to fail; even larger doses may be administered. It is very important to give the strychnine *before* the shock has set in, for when shock is once established remedies are of little avail, and recovery mainly depends on the patient's recuperative power.

Infusion of saline solution into the axillæ is also of great value, especially in young children. The needle should be inserted before the operation incision is made, and an assistant should inform the surgeon of the progress of the infusion, reporting when each ounce of saline solution has run in. For children under three years one to three ounces is usually sufficient. When this method of infusion is practised, the whole of the fluid is not absorbed at the close of the operation, although sufficient has entered into the circulation to maintain the blood pressure. This probably accounts for the fact that the severe collapse, which otherwise so often comes on several hours after the operation has been concluded, does not occur.

In adults a method of *auto-infusion* has been suggested, and in operations such as amputation at the hip-joint or excision of the scapula is often of great value. The limbs which are not being operated on have a tourniquet applied to them as high up as possible without of course any preliminary emptying of the veins. In this way a large amount of blood is segregated from the circulation and does not become saturated with the anæsthetic. At the close of the operation, or whenever necessary, the tourniquets are slowly removed and the blood is allowed to enter the circulation. An ingenious pneumatic suit has also been devised by Crile, especially for cranial operations. The object of this is to maintain the blood pressure by diminishing the capacity of the whole vascular system by exerting uniform pressure on the trunk and the limbs. A similar effect may be obtained by bandaging the limbs from the extremities towards the trunk with either an india-rubber bandage somewhat loosely or a crêpe one firmly applied.

(*b*) **When established.**—When shock is established, vigorous measures must be adopted to combat it. In the first place, *warmth* is of the highest importance; the patient should be wrapped up in warm blankets, outside which hot bottles are placed; benefit will also be obtained by chafing the extremities and the abdomen. He should be put to bed as rapidly as possible and laid quite flat, with only a thin bolster beneath the head, the foot of the bed being raised about six inches so as to favour the flow of blood to the brain, and he should be kept as still as possible so as not to exhaust the heart. A useful measure is to cover the patient with a blanket, place a large cage or cradle outside this and hang electric lights from the top bar of the cradle, covering the whole with blankets.

Free stimulation is also important; perhaps the most rapid stimuant is *ether* injected subcutaneously in doses of from twenty to thirty minims. The point of the needle used for injecting the ether should be buried in the muscle, for sloughing of the skin may occur if a large quantity be injected subcutaneously. The ether may be repeated in fifteen or twenty minutes if necessary, and *brandy* also may be injected in the same quantity still more frequently. Half a drachm of a twenty-per-cent. solution of *camphor* in sterilised almond oil may be injected hypodermically. A hot *nutrient enema* containing half an ounce or more of brandy and two ounces of strong coffee should also be administered, and it may be advisable to give this during the course of the operation if signs of severe shock appear. *Strychnine* and *digitaline* are also valuable, a thirtieth of a grain of strychnine (or a sixtieth if it has been already twice administered during the course of the operation), combined with a hundredth of a grain of digitaline being given and repeated every hour if necessary for three or four doses. *Adrenalin* is also much used at the present time in these cases, and *pituitary extract* has recently been found of value. The latter drug must, however, be given with caution and not in old people, as the blood accumulates in the lungs, and actual hæmorrhage may occur there.

Some authorities lay stress upon the value of *saline infusion*, which is performed as described on p. 112. The effect upon the pulse and the breathing should be carefully watched, and the injection continued until the pulse becomes full, regular, and approaching its normal rate. For this purpose at least two or three pints of the saline solution will be required.

When the infusion is done chiefly for loss of blood, the results are often striking, one injection being sufficient to tide the patient over his danger. When, however, it is performed for pure shock, the effect, although good, is often transient, and the symptoms of shock begin to reassert themselves after the lapse of from a half to three hours, and it may be necessary to repeat the injection even a third or fourth time, the canula being kept *in situ* in the intervals between the injections. This, however, gives rise to such an extreme dilution of the blood as to produce imperfect aëration in the lungs, and sometimes severe dyspnœa may result; if this be the case, the infusion must be stopped, and rectal injections and stimulants substituted. Infusion as a treatment for shock, although worth a trial in bad cases, has not proved so satisfactory in our hands as the writings of some surgeons might lead one to expect; in a case of pure shock the further dilution of the blood can hardly be expected to aid the recovery of the nerve centres. A better method is to inject the saline solution into the cellular tissue of the axilla (see p. 120), and the advantage of this is that dilution of the blood does not occur so rapidly; half a pint or more of the saline solution should be injected into the areolar tissue of the axilla at once, and repeated in an hour if necessary. Still better is the infusion into the rectum drop by drop, as described on p. 115, as soon as the patient has been put back to bed.

These methods are the most suitable ones to employ when the shock has not yet become profound, and, when shock is apprehended, careful watch should always be kept for the early symptoms, so that one of these remedies may be employed in time. When a nutrient enema has been administered, half an hour or an hour must, however, be allowed to elapse before the saline solution is injected. In pure shock stimulants are of much importance, but when there is much hæmorrhage the saline solution is of more immediate value.

Influence of Pain on Shock.—A difficult, but at the same time an important, question is how far severe pain keeps up the shock, and to what extent anodynes may be administered with the view of relieving it. There can be hardly any doubt that prolonged pain will cause exhaustion of the nervous system, and thus prolong or even set up shock, and it is therefore of importance to diminish it if possible. An injection of morphine before the patient comes round from the anæsthetic may diminish shock to some extent, but when once shock is established *morphine* alone is apt to cause a great deal of depression. The addition of *atropine* to some extent removes this objection, and therefore a subcutaneous injection of an eighth to a quarter of a grain of morphine with $\frac{1}{120}$th of a grain of atropine is advisable when there is much pain. It is better to give a small dose and repeat it than to give one large dose.

ENTRY OF AIR INTO VEINS.

This accident is especially apt to happen in operations about the root of the neck on account of the proximity of the heart, and the fact that the veins pass through rigid openings in the deep fascia of the neck. If a vein be opened in these operations and not immediately occluded, air is apt to be sucked in through the proximal end of the vessel during inspiration, and this will give rise to very serious embarrassment of the pulmonary circulation. The right side of the heart becomes full of blood, which is frothy from admixture with air and not readily driven on into the pulmonary artery, and immediate death may be the result. When only a small quantity of air enters, death does not occur so suddenly. The patient then becomes rapidly cyanosed, with quick, deep, almost convulsive respiratory movements as if there were laryngeal obstruction; there is, however, no stridor and the air enters and leaves the lungs freely without relieving the dyspnœa or the cyanosis. This condition usually terminates fatally, but when the amount of air sucked in is very small, the obstruction may be overcome and the circulation re-established. In these cases, it is not uncommon for a small patch of pneumonia to form where the bubbles of air and blood have collected.

The accident is so sudden and dangerous, that the possibility of its occurrence should always be borne in mind by surgeons, especially when operating about the neck, and if veins must be divided, they should be clamped before division if possible; if, however, this cannot be done, the proximal end should be compressed at once by the finger, so as to prevent the accidental entrance of air; a clamp is then put on as quickly as possible and the operation is not proceeded with until the divided ends of the vein have been closed. The accident is most likely to happen when a vein has been only partially divided, and when the rent in its wall is made during the surgeon's manipulations, as for instance in pulling forward the thyroid gland during thyroidectomy. A characteristic hissing sound is heard as the air enters the vein, and an operator who is on the look-out for this complication may thus detect it before there is time for the general symptoms to develop.

TREATMENT.—If symptoms pointing to entry of air into a vein arise during the course of an operation, digital pressure should be made over the divided vein immediately, and the wound flooded with saline solution so as to prevent further entry of air. The next point is to try to force the air out from the vessels in the chest by forcibly compressing the chest, while at the same time the pressure on the vein is relaxed so as to allow the air and frothy blood to be poured out through its open end; the vein is again compressed when the chest is allowed to expand, and so on. The removal of the frothy blood may also be attempted by aspirating the vein; a small tube, such as a sterilised catheter, is introduced into it, the end of the vein compressed tightly around it, and then an attempt made to suck the froth out. As a rule, however, death is immediate when a large quantity of air has passed in.

SYNCOPE.

Syncope is not an infrequent complication of operations; by the term is meant complete arrest of the heart's action, accompanied by loss of consciousness. In shock, on the other hand, the loss of consciousness is not complete and the pulse is always to be felt, although it is often very feeble. Syncope or faintness may result from sudden loss of blood; from withdrawal of blood to another part, as in tapping the abdomen for ascites; or reflexly from sudden nervous shock, especially if the patient be not fully anæsthetised. When the patient is not under an anæsthetic, syncope is usually preceded by vertigo, tinnitus, nausea, and imperfect sight, and these symptoms are followed by arrest of the heart's action, cessation of bleeding, marked pallor, dilated pupils, a cold sweat over the forehead, cold extremities, feeble or absent respiration, and total loss of consciousness. The condition is due to deficient supply of blood to the brain. Except in extreme cases, the arrest of the heart's action is only momentary, and recovery is indicated by sighing and gasping respirations, reappearance of the pulse, and gradual return of consciousness.

In the **treatment** of syncope it must be borne in mind that the symptoms are essentially due to absence of blood from the brain, and steps should be taken to remedy this. Before syncope is fully established it is often sufficient to depress the patient's head well between his knees, so that it is at a considerably lower level than the heart, when the face will flush and the feeling of faintness will pass off. When syncope is established, it should be an invariable rule to lower the patient's head at once; there is nothing more dangerous than to leave him sitting up, or with his head reclining upon a pillow; the heart may not act again in time to supply blood to the vital centres while recovery can still take place. It is well also to elevate the legs so that any blood present in the lower extremities may run back into the larger vessels. The chest also must be free, and there must be nothing tight around the neck. Sudden shocks to the external surface will set up the heart's action again, the favourite plan being to bare the chest and dash cold water over it, or slap it with wet towels. Cold water dashed over the head, or brandy rubbed on the lips and gums, has similarly a good effect. There must be plenty of fresh air; no crowd should be allowed to gather around the patient, and when he is able to swallow, a little brandy-and-water, or other stimulant, will aid recovery.

When syncope occurs during the course of an operation, the patient should be pulled up to the end of the table and his head allowed to hang over it, or the foot of the table may be tilted up. Artificial respiration may be required, and slapping the chest with wet towels; the application of the Faradic current to the region of the phrenic nerves may be of considerable help. This is best done by means of two moist electrodes about the size of a shilling, connected with an induction coil, which are pushed forwards beneath the posterior edge of the sterno-mastoid just above the clavicle on each side, and a current of five to fifteen milliampères then made and broken from fifteen to thirty times per minute. Each closure of the current causes an inspiration, followed by an expiratory effort. There is, however, a risk of stimulating the vagi and still further embarrassing the heart. Direct stimulation to the region of the heart seems to do no good and may be actually harmful.

AFTER-TREATMENT OF OPERATIONS.

After the operation is completed, the patient should be put to bed as quickly and gently as possible, and wrapped up in warm blankets. In most cases he should lie on his back with only a thin bolster under the head. The room should be rapidly cleared and darkened, and the patient left perfectly quiet. If this be done, the narcosis may pass into ordinary sleep, which may last an hour or two, and the patient may have no pain at all when he wakes up; at any rate, the worst of the pain will have passed off, and the sickness will not be so great. If the patient be at all collapsed an enema of hot saline solution (100° F.) should be given as soon as he is back in bed. At least a pint should be given.

The recumbent position is required, in most cases at any rate, until the sickness has passed off, but the rigidity with which this is enforced is becoming relaxed, and many patients are now allowed to assume a more upright position almost immediately after an operation. While sitting a patient up in bed, the pulse must be carefully watched, and the patient laid flat on his back if it show any sign of failing. The surgeon must use his judgment as to the immediate administration of morphine or heroin.

The patient should always be seen on the evening of the operation in case he be in pain, for which morphine may be necessary; in case any bandage be too tight and require cutting; also in case there be retention of urine, which may occur not only after rectal and perineal operations, but sometimes in other cases. Other troubles of which the patient may complain are the occurrence of colicky pains and pain in the loins. Colicky pains are common after abdominal operations, and seldom subside entirely until the bowels have acted; they can be diminished by enemata and the passage of a long rectal tube. Pain in the back is a very common complaint with people who have been in vigorous health before the operation, especially when the operation has been prolonged and the patient has to lie on his back afterwards. This passes off in twenty-four or thirty-six hours, but while it lasts it causes considerable discomfort. Aspirin in doses of fifteen grains generally relieves this; if necessary, it may be given in a saline enema. A pillow or an india-rubber hot-water bottle under the back also relieves it to some extent, and when we expect that it may happen—*e.g.* in prolonged operations—it is well to place a pillow under the loins when the patient is put upon the operating table.

Feeding.—Neither food nor drink should be given for three or four hours after the operation; at most, a small quantity of very hot water or a teaspoonful of brandy-and-water if absolutely necessary. At the end of that time beef-tea may be given if the patient desire food, and this may be alternated with milk-and-soda after about six hours, if there be no sickness. A cup of hot weak tea is often the first thing that the patient relishes.

It is well not to push the feeding for the first twenty-four hours, unless the patient be very weakly, and even then two or three nutrient enemata or zyminised suppositories administered at intervals of four hours are better than feeding by the mouth. If feeding by the mouth be commenced too soon, or pushed too energetically, it is apt to bring on serious sickness. For the treatment of vomiting after an anæsthetic, see p. 478. In babies still at the breast, feeding can be discontinued until the child seems anxious for food. No attempt should be made to force the child to take the breast, but if he seems to want to do so, it may be permitted without risk. Very young children are much less sick, and are generally in less discomfort after operations than adults.

In cases where asepsis is obtained, the patient is free from pain by the next day at latest, and rapidly regains his normal strength and requires little further attention. If the operation has been a severe one, it may be well to keep him on slops—*e.g.* beef-tea, chicken-broth, milk, a little champagne or other stimulant—for forty-eight hours after the operation, and to commence solid food on the third day; he may have his ordinary diet a day or two later. When the operation has not been severe, and there has been no sickness, no restriction need be placed on the diet after the first twenty-four hours.

Pain.—If the patient be in severe pain or be very restless, morphine may be required. But it must be remembered that this drug is not without serious disadvantages; its use is often followed by flatulence and constipation, and may be accompanied by much headache, nausea, and depression, thereby distinctly increasing the patient's subsequent discomfort. If the patient can tolerate the pain, his condition next day will probably be better than if morphine had been administered. If required, the drug should be given in doses of an eighth to a quarter of a grain. Heroin (gr. $\frac{1}{12}$) or aspirin (gr. 15) is often useful also for post-operative pain. The latter drug is specially useful for backache after operations.

Aperients.—The patient is seldom quite comfortable until the bowels have been cleared out, and this should be effected on the second or third day after the operation. The best plan is to administer a dose of castor oil in the evening, followed by a Seidlitz powder or an enema in the morning. This does not apply to such operations as those upon the rectum, etc., where it is often essential to keep the bowels confined for some days. If there be severe flatulence, great relief can often be obtained by a turpentine enema. This may be prepared in one of two ways: In the first, an ounce of turpentine is beaten into an emulsion with about four to six ounces of thin gruel, the yolk of an egg being added to aid in the emulsification; this is injected into the bowel first, and is followed by a large simple soap-and-water enema. In the second, the turpentine is simply stirred into the soap-and-water and the whole injected together. For minor degrees of flatulence the flatus-tube is often found to be of service. This is a stout india-rubber tube about twelve inches long, with a terminal opening; it is passed into the bowel as far as possible, and may be with advantage left *in situ*. Change of position, sitting the patient up or turning him on his side, often helps in getting rid of flatus.

There are certain points special to individual groups of cases, such as the length of time the patient must be confined to bed, etc., which cannot be dealt with here, and will be found in connection with the after-treatment of the individual operations concerned.

CHAPTER VI.

MODES OF HEALING OF WOUNDS.

Before discussing the treatment of wounds, it may be well to refer to the modes in which they heal. There are five methods by which healing may take place—namely, by first intention, by blood-clot, under a scab, by granulation, and by union of granulations. The particular form of healing which occurs depends, in the first place, on whether the edges of the wound have been brought together or remain apart; and, in the second place, on whether causes of suppuration gain access to the wound, either at the time of its infliction or subsequently.

The immediate result of the infliction of a wound is bleeding, and blood-clot forms on the cut surface. When this clot is wiped off, it is found that exudation of lymph is taking place beneath; in other words, a thin microscopic layer of inflammation, going as far as the end of the first stage—namely, exudation—has been set up as the result of the irritation of the knife and the contact of foreign bodies. The result in all wounds, whatever their nature, whether the edges have been brought together or not, is that lymph (*i.e.* fibrin entangling white corpuscles) is poured out and glazes the surface.

HEALING BY 'FIRST INTENTION.'

When no further causes of inflammation come into play, notably when no bacteria are present between the cut surfaces, this lymph remains and glues the edges of the wound together if they have been brought into apposition. It then soon becomes infiltrated with cells; at first leucocytes, and, later on, other cells from the surrounding tissues pass into it. These apparently feed on the remains of the white corpuscles and destroy them, and they themselves enlarge, become spindle-shaped, and form young fibrous tissue. The result is that, while after the first twenty-four hours the two cut surfaces are separated by a layer of young cells, in the course of three or four days the cells have become spindle-shaped, and some of them are already forming young fibrous tissue. New blood-vessels are also developed very much in the same manner as in the embryo. As time goes on, the fibrous tissue between the two cut surfaces becomes more perfect and contracts, thus shortening the incision and temporarily depressing its surface; the newly formed vessels also tend to disappear. Later on, this new fibrous tissue becomes converted into areolar tissue; when it is situated in the middle of fat, fat-cells form in it, and the scar therefore becomes looser.

About the second or third day, the epithelial cells on the surface begin to spread over this narrow line of young cellular tissue, so that there is generally a continuous layer of epithelium from one edge of the wound to the other at the end of the fourth or fifth day. This process is termed primary union, or healing by first intention, and it ought to be aimed at in all cases, because there is no general disturbance, no fever, and no septic trouble in connection with it, while the resulting scar is small and, after a time, almost unnoticeable.

Conditions Inimical to Healing by First Intention.—In order to obtain healing by first intention (which should always be aimed at in incised wounds), it is essential, in the first place, to bring the edges of the wound together, and, in the second place, to avoid anything which may lead to inflammation. Among the minor conditions which tend to prevent union by first intention are, first, mechanical irritation of the part, more especially in the form of movement either of the part itself or of the muscles beneath it; secondly, the presence of unduly tight stitches; thirdly, the irritation of dressings, or of the chemical substances contained in them or used as lotions. The most common cause, however, which leads to the failure of union by first intention or by blood-clot, and which exposes the patient to the various serious risks to be mentioned later, is the entrance of micro-organisms and their growth either in the material on the surface of the wound or in the tissues themselves. The organisms which act in this way are essentially the pyogenic organisms, and they consist of various kinds of micrococci, known as the pyogenic cocci, the chief of them being the staphylococcus pyogenes aureus, staphylococcus pyogenes albus, and streptococcus pyogenes. These organisms growing in a wound peptonise the materials on the surface, and so lead to the destruction of the original tissue, while they produce chemical substances of great potency, which act locally by causing, first, granulation, and subsequently suppuration, and, generally, by setting up febrile disturbance.

These micro-organisms are constantly found on the surface of the skin and mucous membranes, more particularly in parts where the skin is moist—as, for example, in the perineum, the axilla, between the toes, and in the dirt under the nails. They grow in the old epithelium on the surface of the skin around the hairs, and they also appear to penetrate into the orifices of the sebaceous and hair follicles. They vary in virulence, and the different kinds vary also in their mode of action. For example, the staphylococci are specially prone to cause the circumscribed abscesses, whereas the streptococci spread along the lymphatics, causing diffuse cellulitis, or gain access to the blood-stream and set up pyæmia.

HEALING BY BLOOD-CLOT.

When the edges of the wound have not been got into accurate apposition, the space between the cut surfaces becomes filled with coagulated blood, whilst the surfaces themselves are covered with lymph. When no further causes of inflammation come into play, this blood-clot may remain and form a mould in which the young cells develop and form fibrous tissue and fresh blood-vessels. When nearly the entire blood-clot has become organised, epithelial cells begin to spread over this imperfect tissue from the sides. In small wounds a thin layer of the top of the blood-clot can often be peeled off at the end of about fourteen days, leaving an epithelium-covered surface beneath. This process may be termed healing by blood-clot; and, although it is only visible when the edges of the wound do not come together, it occurs to some extent in almost all wounds of any depth, because the deeper parts of a wound are seldom in such accurate contact that only a thin layer of lymph divides them; when there is any appreciable separation, blood-clot forms between the raw surfaces and undergoes organisation as described above. Hence, even in wounds that apparently heal by first intention, that process only takes place as a rule towards the surface, while the deeper parts heal by blood-clot.

HEALING UNDER A SCAB.

The process of healing by scabbing is practically the same as healing by a thin layer of blood-clot. The superficial layer of lymph and blood dries up and forms a scab, which protects the surface of the wound from irritation, and organisation goes on in the thin layer of lymph beneath, while epithelial cells spread in beneath the scab.

HEALING BY GRANULATION.

When a wound becomes irritated, or when sepsis is present, healing takes place by granulation. When this happens, the edges of the wound have either not been brought together, or, if they have, union by first intention has failed, owing usually to the occurrence of sepsis. As in both the preceding cases, effusion of lymph occurs as the first change; but the process of inflammation does not stop there. Since the causes of irritation continue to act, the inflammation goes on to the second stage—namely, granulation—so that all the structures exposed in the wound become covered with granulation-tissue. This soon becomes arranged in the form of little rosy buds, termed granulations, which on microscopical examination are seen to be composed of actively growing cells with numerous young blood-vessels. The granulations ultimately fill up the wound, and epithelium begins to spread over their surface when they are nearly level with the skin. While this process is going on, the cells of the granulation-tissue in the deeper parts of the wound, being protected from irritation by the granulations on the surface, develop into young fibrous tissue, and large numbers of the blood-vessels become obliterated. This young fibrous tissue at once begins to contract, and the edges of the wound become drawn together, so that, even before the spread of epithelium has commenced at the surface, the wound may be much smaller than it was when first made.

When the young epithelial cells begin to spread over the surface of the sore, a delicate red line is found around its edge, because at first the epithelial cells are young, transparent, and only in a single layer, and therefore they allow the red colour of the granulation-tissue to show through. At a later period the epithelium becomes thicker, and a bluish appearance is the result; still later, when the epithelium has been formed for some time, the thick layer on the surface becomes macerated and white, like the skin of a washerwoman's hand, and there is a white line formed. Thus, there are three zones in a healing wound—an outer white line shading off into a blue one, and this again shading off into a delicate pink line. In many cases this pink line is not noticeable until the wound has been dried, when it will be seen that, while the granulations on the surface of the unhealed part begin to ooze and become moist, the red line at the edge of the wound remains dry. The detection of this red line is of importance, because it implies that healing is in active progress.

In the final stages of healing by granulation the new epithelium becomes thicker and thicker over the surface, so that for some weeks epithelial scales are constantly forming. Later on, the wound contracts, and this contraction may lead to very serious deformity. The structure of the scar undergoes continued alteration until ultimately it is composed of a mass of fibrous tissue covered with epithelium, and containing very few blood-vessels; there is no development in it of the special structures of the skin, such as hairs and sebaceous or sweat glands.

During the process of healing by granulation, the patient is exposed to the risk of severe local and general troubles arising from the various infective diseases due to bacteria which may gain entrance through the open wound. In any case, unless the wound be aseptic or very small, there is a certain amount of fever ('traumatic fever') during the formation of the granulations, which is due to the absorption of poisonous products from the decomposition in the wound. When granulation is complete—that is to say, about the third or fourth day—the temperature falls and the fever disappears, because the granulations do not permit absorption of these poisonous products.

Apart from the danger of sepsis, a drawback to this mode of healing is that the scar is larger than after healing by first intention, and the deformity due to the contraction of the scar is sometimes very serious; it is evident, therefore, that healing by granulation is not such a desirable process as is union by first intention.

HEALING BY UNION OF GRANULATIONS.

In this mode of healing the edges of the wound are not brought together in the first instance, but are intentionally kept apart with dressings until both surfaces are granulating, when the surfaces are washed and brought together. The result is that these granulating surfaces adhere over a considerable area and union occurs rapidly; but the risks attendant on healing by granulation, to which reference has just been made, apply to this method of healing also. It is not a mode that should be deliberately chosen when other methods are available, but it is well to bear in mind that healing may occur in this way.

CHAPTER VII.

THE TREATMENT OF INCISED WOUNDS.

The great object of wound-treatment is to prevent the entrance of organisms into the wound, or, when this is impossible—as, for example, in operations about the mouth or the rectum—to hinder their growth, and thus minimise their evil effects. These objects are effected in two ways. The primary one is to disinfect the skin of the patient and the hands of the operator and his assistants, together with all the instruments and accessories used in the operation, so thoroughly that no organisms are thereby introduced into the wound. A secondary, but very important, object is to kill or inhibit the growth of any organisms that may accidentally gain access from any cause.

CLASSIFICATION OF INCISED WOUNDS.—There are two great classes of incised wounds—viz. those made by the surgeon, and those inflicted before the patient is seen by him. Wounds made by the surgeon may be again subdivided into — (*a*) those made through unbroken skin and not communicating with mucous surfaces ; (*b*) those made in connection with previously existing sinuses or suppurating deposits, or communicating with some mucous canal. The importance of this subdivision is that, while it is comparatively easy to exclude micro-organisms from wounds of the first class, it is always difficult and may be impossible to do so in the second variety ; the treatment in the latter must therefore be directed towards minimising the ill-effects produced by the organisms after they have gained entrance.

TREATMENT OF WOUNDS MADE BY THE SURGEON THROUGH UNBROKEN SKIN.

It is clear from what has gone before that the point to be aimed at here is healing by first intention. If this be obtained, there is rapid recovery, and a delicate scar is left, which becomes practically invisible later on, while the general septic affections or the local inflammatory troubles which may occur if union by first intention be not obtained are avoided.

The conditions which favour healing by first intention have already been referred to (see p. 128); of these, the absolutely essential one is asepsis of the wound; in addition to this, however, care has to be taken to bring the cut surfaces of the wound into accurate apposition. Besides this, causes of unrest, such as movement, irritation by the dressings, etc., must be avoided.

Apposition of the Edges.—The cut surfaces of the wound must be in accurate apposition; if not, an interval is left which becomes filled with blood-clot, and although healing by blood-clot will occur if the wound be aseptic, it is not so good as union by first intention. When the edges of the wound are brought into apposition, the two should be on the same level. If one be higher than the other to a very slight extent it will not matter, except in so far that the subsequent cicatrix will not be a fine delicate line, but will show a definite ridge. If, however, there be

A B

FIG. 33.—FAULTY METHOD OF SUTURING A WOUND.—In A the suture is in place; it causes the skin on one side to overlap that on the other. In B is seen the gap left when the suture is removed.

any marked difference in level between the edges, and especially if the raw surface of the one side be in contact with the cutaneous surface of the other, healing of the overlapping raw surface may not take place although the deeper parts will unite satisfactorily. Epithelium will not spread over a raw surface which is lying in contact with epithelium-covered skin; and in such a case it is necessary, in order to obtain healing, to pare away the inverted or overlapped edge of the skin, and thus to have two raw surfaces opposed to each other.

Approximation of the Deeper Structures.—When a wound has to be closed, its deeper parts must be approximated as well as its cutaneous edges. For this purpose some surgeons employ deep stitches, and then put in superficial ones to bring the skin together; this, however, is hardly necessary in the great majority of cases. By properly applied pressure outside the wound (see p. 151) it is generally possible to bring the deeper parts sufficiently together, and then stitches need only be employed for the approximation of the edges of the skin. In some cases, however, deep stitches may be required; for example, when the incision has been carried through dense fibrous tissue, as in excising a portion of the breast, a cavity may be left which will fill with blood-clot unless the deeper parts

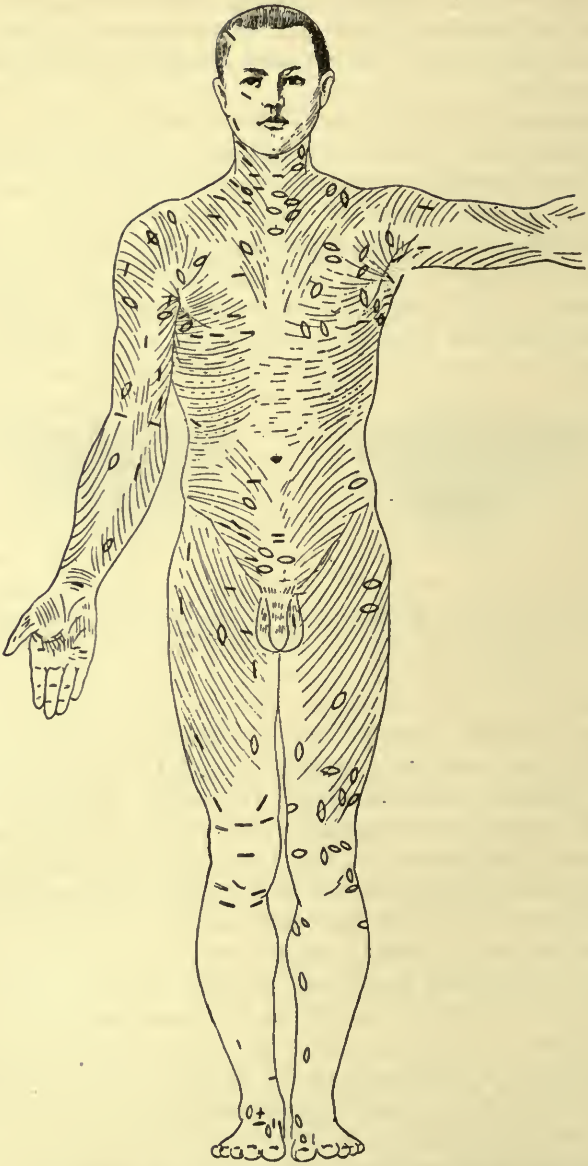


FIG. 34.—ANTERIOR VIEW OF THE BODY ILLUSTRATING THE DIRECTIONS IN WHICH INCISIONS SHOULD BE MADE.—The correct incisions are indicated by the single dark lines. In them the lips of the wound tend to fall together, while those of the faulty incisions—denoted by ellipses—tend to gape. (This and the following figure are reproduced from Kocher's *Operative Surgery*, 2nd English edition 1903.)

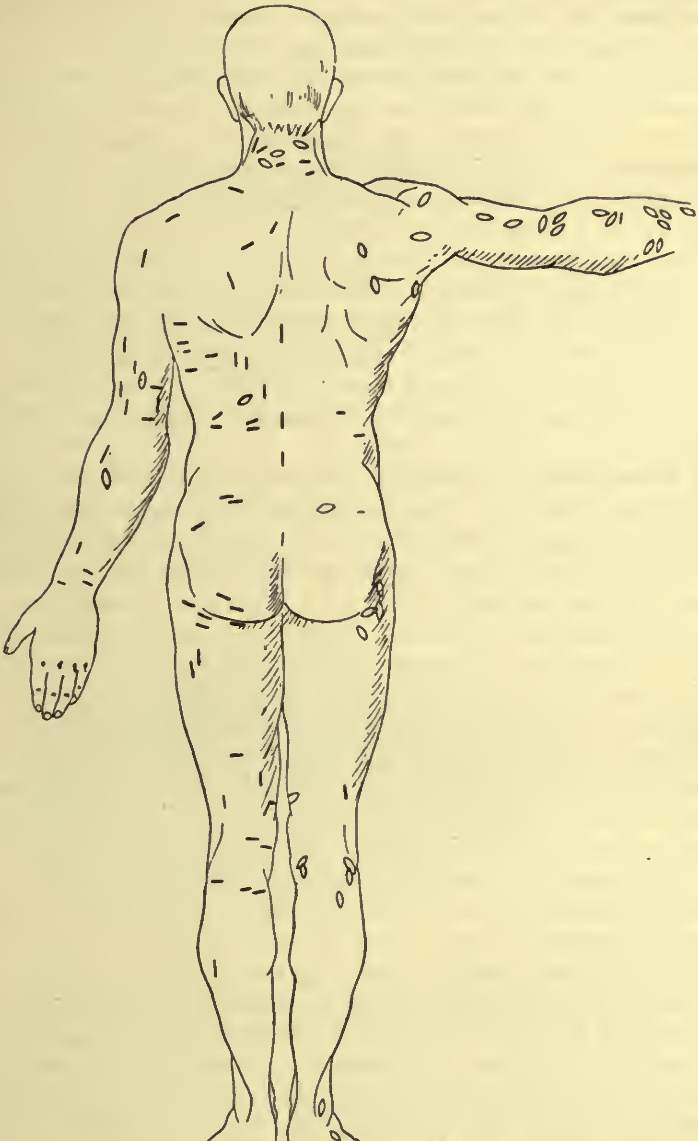


Fig. 35.—Posterior View of the Body Illustrating the same Point.

be approximated; this may interfere materially with healing. Again, when a strong layer of fascia, such as the fascia lata, has been divided, it is advisable to suture this before the wound is closed. Sometimes deep sutures may be required to relieve tension upon the skin-edges where a delicate scar is of importance (see p. 137).

Sutures.—The choice of the material for stitches is determined by the asepticity of the wound and the amount of tension upon its edges. As we are now dealing only with aseptic wounds, we shall only consider the question of stitches in (*a*) those in which there is no tension on the edges; (*b*) those in which the tension is great; and (*c*) those in which it is only moderate in amount. It is well to bear in mind, in connection with wounds on the face or neck, that more unsightliness is produced by the stitch-marks after healing by first intention than by the cicatrix itself; therefore, under these circumstances, the avoidance of stitch-marks is a matter of considerable importance. Whatever be the material used for stitches it must be sterile; this point is fully dealt with on p. 93, where the method of preparing, storing, and using each is detailed.

(*a*) **When there is no Tension.**—When there is no tension on the edges of the wound, and when as delicate a scar as possible is desired, as in operations upon the face and neck, the finest material only should be used, and the stitches should not be put closer together than is absolutely necessary to keep the edges in contact; they should be inserted as close to the line of incision as possible. Under these circumstances fine *horse-hair* or silkworm-gut is probably the best material to employ. The size of the stitch-marks may be reduced still further if a fine sewing-needle be employed. When, however, there is no special reason for avoiding stitch-marks, the best and quickest plan is to close the wound by a continuous button-hole suture of fine silk, using the ordinary triangular straight needle. This suture is described and illustrated on p. 142.

How to obtain a very fine Scar.—This is a point of importance in operations on the face and neck.

The first essential point is the direction of the incision. The skin is not a homogeneous structure, but has distinct lines of cleavage which run roughly at right-angles to the long axis of the body. Their exact distribution is shown in Figs. 34 and 35. Incisions made along these lines produce much finer scars than those made at right-angles to them.

The second point is to avoid tension on the skin. To accomplish this in some cases it is necessary to insert deep buried sutures so as to bring the deeper parts of the wound together. This is specially important when it has been necessary to remove portions of the skin. In operations on the neck it is well to suture the platysma and deep fascia with fine catgut.

The third point is the method of inserting the sutures. Several methods may be adopted.

Buried Sutures.—An excellent way of introducing a buried suture is to take a curved Hagedorn needle, threaded with the finest *catgut*, and pass it through the fat and deeper part of the dermis on one side of the wound, and then through the fat and deeper part of the dermis on the other, the needle being made to enter the fat and emerge through the dermis on the one side, and *vice versâ* on the other. Several stitches

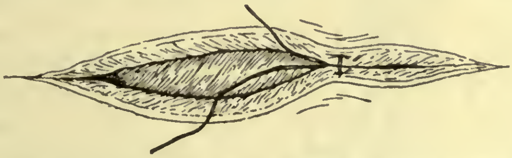


FIG. 36.—A BURIED SUTURE. The figure shows how, by making the free end of the suture emerge on each side through the deeper part of the dermis and the adjacent subcutaneous tissues, the knot can be pushed out of the way among the fat when it is tied. If it were done in the reverse way the knot would lie between the lips of the incision, and would interfere with coaptation. The ends of the suture are cut short and pushed down out of the way with a probe.

are passed, and they are then tied and the ends cut short, the knot being pushed down into the fatty tissues beneath the dermis (see Fig. 36). These sutures hold the deeper parts of the skin firmly together. A strip of gauze is then fixed upon one side of the wound with collodion, and when this is dry, the skin on the other side is pressed inwards towards the line of incision and the free end of the gauze strip is fastened down

FIG. 37.—HALSTED'S INTRA-DERMIC SUTURE.—The suture, which is commenced at one end of the incision, is grasped in a pair of pressure forceps, passed across and across the wound in the substance of the dermis and finally brought out at the opposite end of the incision. The wound is closed by making traction on the ends of the suture.

upon it with collodion. As far as the gauze and collodion are concerned, the procedure closely resembles the old-fashioned method of applying strapping to draw the edges of wounds together, and is similar to the plan that is often adopted in hare-lip operations. The epithelial edges are thus approximated, and stitch-marks are absolutely avoided, so that only a very delicate linear scar is left, which in a short time becomes unnoticeable.

Halsted's Intra-dermic Suture.—Halsted has modified the buried suture by inserting a single silkworm-gut or catgut suture in the manner shown in Fig. 37.

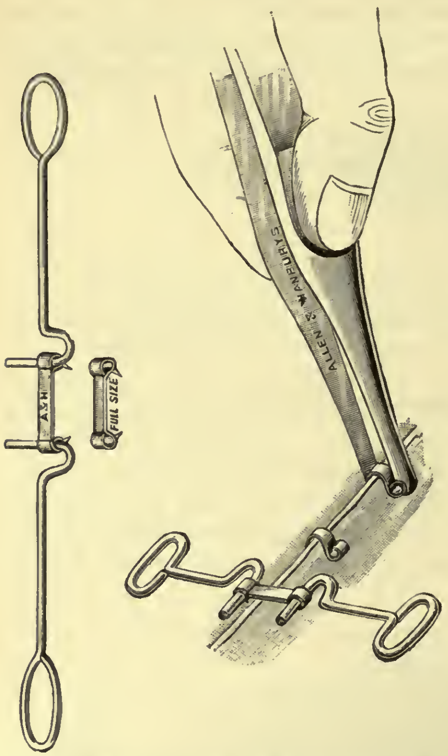


Fig. 38.—Michel's Clips.—The sketch shows both the method of applying the clips by pinching them up with special forceps, and that of removing them by inserting the special hooks and straightening them.

This method is, however, only suitable for short and straight incisions and requires a good deal of practice to perform quickly and efficiently. A special long, slightly flexible needle is of advantage.

Michel's Metal Clips. — These are small pieces of malleable white metal bearing a small spike at each end. Before insertion of the suture these spikes project at right-angles to the long axis of the clip, but when the latter is bent into a semicircle they point inwards towards one another. The edges of the wound are held in apposition with two pairs of fine toothed forceps so as to produce a slight ridge with the incision at the top of it; the clip is then held in a special pair of dissecting-forceps (each blade being grooved to receive the ends of the clip) over the ridge, and the clip is bent by gentle pressure on the forceps so as to force the spikes lightly into the skin. If too great pressure be exerted in applying these clips there will be sloughing of the skin between their ends. The clips are inserted about half-an-inch apart along the whole length of the incision. The clips should be removed about the fifth day, preferably with the special instruments sold for the purpose; if these be not available, one blade of a Spencer Wells's forceps may be passed into the concavity of the clip and the blades closed; this flattens out the clip and so liberates its points.

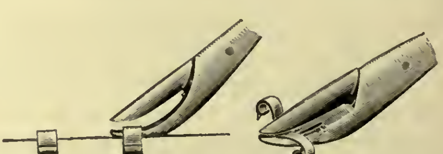


Fig. 39.—Removal of Michel's Clips by Forceps.—Ordinary Spencer Wells's forceps can be used, but special forceps, shown in the figure, are made for the purpose.

If properly applied, these clips leave little to be desired, but if they happen to slip, a very inaccurate and unsightly scar may result; moreover, even after considerable practice, it is impossible to gauge the pressure they exert so accurately as to be sure that no sloughing will ensue—a most important matter in wounds upon the face and neck. They are rather more painful than ordinary sutures.

FIG. 40. — LISTER'S NEEDLE FOR THE INTRODUCTION OF SILVER WIRE.

If all tension can be removed by deep sutures, admirable scars may be obtained by the use of fine continuous horsehair sutures inserted with a fine round sewing-needle at the very margin of the incision. The round needle-point pushes aside the fibres of the skin and does not divide them as triangular needles or those with cutting edges do. The sutures should be removed on the fourth day and a piece of gauze fixed on with collodion as described above (see p. 137).

(*b*) **When there is Great Tension.**—After operations for the removal of tumours—as, for example, carcinoma of the breast—there is often a great deficiency of skin, and the edges of the wound will not come together without considerable traction. If the skin be pinched up by an unduly tight stitch, persistent irritation is caused, and union may fail; at any rate it will not be so rapid and firm as it should be. When inserting sutures, therefore, it is important to see that no stitch is tighter than is necessary to approximate the edges of the skin. When there is much difficulty in bringing the edges together, however, some irritation must necessarily be caused by the stitches; but this can be largely reduced by introducing a few so-called 'stitches of relaxation' (Lister) at some considerable distance from the edges of the wound. The tension upon these may be great, and they may subsequently cut through the soft parts to a certain extent; but they serve, temporarily at any rate, to relax the tension upon the edges of the wound, which may then be stitched together without any tension, with the result that they will heal by primary union. Hence, two classes of sutures are used when the edges of the wound require to be pulled together—namely,

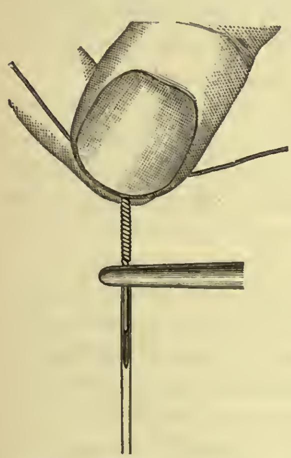


FIG. 41.—METHOD OF THREADING LISTER'S NEEDLE WITH SILVER WIRE.

'stitches of relaxation,' and others which may be termed 'stitches of coaptation.'

'*Stitches of Relaxation.*'—Stitches of relaxation require to be inserted at a considerable distance from the edges of the wound, and must be reasonably stout, because a fine stitch would cut its way out too quickly; the best material for this purpose is thick *silver wire* (Nos. 1 or 2 gauge), threaded into special *needles*, 'Lister's pattern' (see Fig. 40). The wire is threaded through an eye which is at some distance from the end, while between the eye and the end of the needle there is a groove, into which the wire is pressed, so that where the needle goes the wire follows without any unnecessary tearing of the structures through which it passes. In threading these needles, two or three inches of the wire are passed through the eye and flattened carefully into the groove on each side; the needle is then held with forceps, and the two ends of the wire are carefully twisted together (see Fig. 41). If one end of the wire be merely twisted round the other, a number of projections are left, which catch in the wound when the stitch is pulled through. Pure drawn silver wire without any alloy must be employed; its properties and the method of sterilising and preparing it for use are described fully on p. 95.

If the tension be not very great, the wire is tied into the first half of a reef-knot, the ends are turned up at right-angles and then clipped off flush with the surface of the wire (see Fig. 42); if the wire be stout, it will hold perfectly well, while there is no projecting end left to catch in the dressing. When the tension is great, a second twist must be made and the ends cut off and bent down on to the skin. The ends of the wire may be prevented from catching in the dressing by interposing a layer of oiled silk protective between them and the wound. Enough of these deep silver-wire stitches must be put in to enable the edges of the wound to be brought together without any tension.

Undermining Flaps.—When much skin has been taken away, it is often impossible to suture the edges accurately unless the skin be freed by undermining it widely. By this means the skin and fat are separated from the deeper parts for a considerable distance, and the elasticity of the skin allows the flap thus formed to stretch, and the cut edges to meet. Full details of the method will be found on p. 157.

Button Sutures.—When the tension is very great, the 'button sutures' introduced by Lord Lister may be employed with advantage. A needle threaded with stout silver wire, as described above, is inserted through the skin several inches from the edge of the undermined flap, at the outer limit of the undermining, and the free end of this is attached to a lead button (see Fig. 42). The wire is then carried across the wound, and the needle brought out through the skin at the corresponding spot on the opposite side where the undermining ceases. The needle is then cut off, and over the cut end of the wire is threaded a second button, which is pushed as far down as possible, while firm traction is made on the wire, and the button is then secured in place. Only a few of these button stitches need be inserted; as a rule, two pairs suffice in a breast case. The larger the button used the better; the pressure is then more evenly distributed over the skin, and there is less likelihood of sloughing from its pressure. In order to avoid this, it is well to adopt the precaution of inserting a small wad of gauze between each button and the skin; a small slough generally forms where the wire penetrates the skin, but this causes

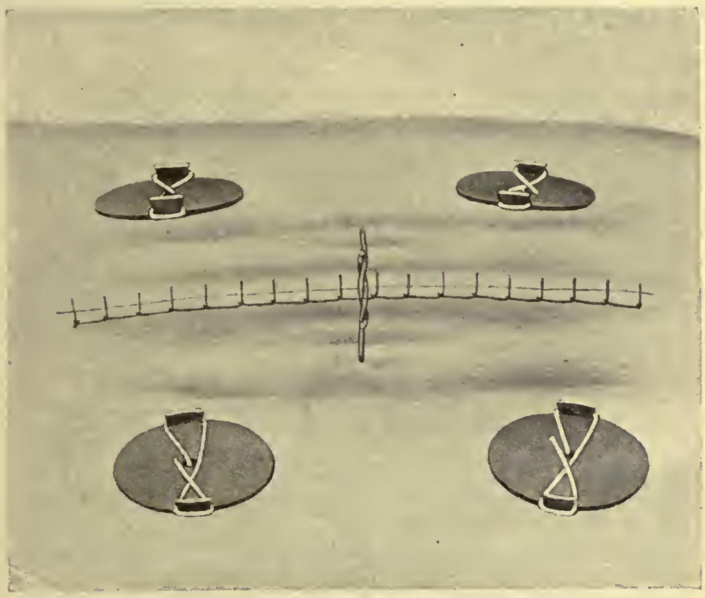


FIG. 42.—METHOD OF SUTURING A WOUND WHERE THERE IS MUCH TENSION ON THE EDGES. On either side is a pair of button sutures, showing the figure-of-eight arrangement by which the wire is fastened. In the centre is a relaxation stitch of stout silver wire showing the manner in which the wire is tied and its ends clipped off. A continuous 'button-hole' stitch unites the edges of the skin which, by the aid of the button sutures and the silver wire stitch, come together without tension. The puckering of the skin caused by the tension upon the button sutures and silver wire stitch is also indicated. The skin has been freely undermined.

no trouble in an aseptic wound, and heals readily when the buttons are removed. Several 'stitches of relaxation' inserted midway between the buttons and the edge of the wound (see p. 140) will also be required to take off tension from the edges of the wound.

The button stitches are usually left in for about five or six days; they are the first sutures to be removed, partly because the skin will not retract after being stretched for that length of time, and partly because they are apt to cause a slough if they are in longer.

(*c*) **When there is Moderate Tension.**—When only moderate traction is required to bring the edges together, a very good material for a stitch, and one that is intermediate between one of 'relaxation' and one of 'coaptation,' is *silkworm or fishing gut.* This should be fairly thick, and, if a good hold of the skin be taken, the latter can be made to bear a considerable amount of tension without bad results.

'*Stitches of Coaptation.*'—It was formerly the practice to use interrupted sutures to bring the edges of the wound accurately together, each suture being separately inserted, knotted, and divided. Most surgeons now employ a continuous suture, which has the advantage that the edges are more accurately approximated by it and that it is much more rapidly inserted, a point of importance when a large wound requires to be closed at the end of a long or severe operation.

FIG. 43.—METHOD OF INSERTING THE BUTTON-HOLE SUTURE.—The sketch shows how the needle is brought out inside the loop formed by the thread from the last section of the stitch.

The best form of *continuous suture* is that known as the blanket or *button-hole stitch* (see Fig. 43). The suture is first inserted at one end of the wound and tied; then, instead of cutting the thread, the needle is passed through the two edges of the wound, and brought out inside the loop formed by the thread, and drawn tight, and this is continued till the whole wound is stitched up; the end may be secured either by leaving the last loop long and tying a knot between it and the free end of the thread, or by taking several turns of the thread around the needle as it forms the last loop and then tightening it up (see Fig. 44). The result is that along one side of the wound there is a continuous thread of silk, which acts very like the old quilled suture.

This stitch is better than the running suture, which tends to pucker up the edges, if drawn tight, and may even cause gangrene of portions of them. If the dressings have been allowed to dry, the threads will be found stuck together with blood after a few days, and if any one of the stitches be too tight, it can be divided or removed without the rest of the stitch necessarily giving way. The best material for the continuous suture is silk, of the variety known as Chinese twist, varying in thickness according to the tension to which it is exposed. When there is no tension, quite a fine silk is sufficient ; but when there is much, it is better to use silk

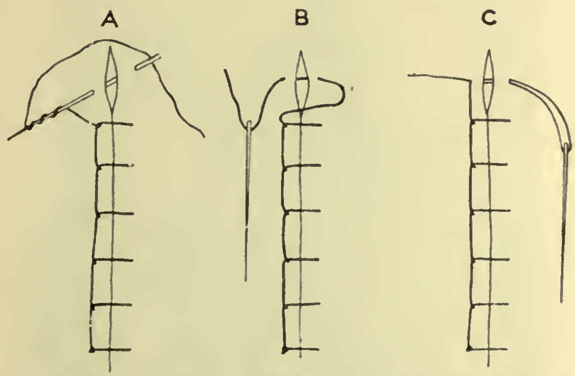


FIG. 44.—METHODS OF FINISHING OFF THE BUTTON-HOLE SUTURE. A. As the needle emerges through the skin for the last time, the thread is twisted around it three or four times. The needle is then pulled through and the stitch pulled tight. A perfectly satisfactory knot can be thus made with a little practice. B. Shows a method very commonly used. When the needle is passed through the skin for the last time it is not brought out inside the loop from the last stitch ; the free end shown on the left-hand side of the incision is taken in one hand, the loop shown on the right-hand side in the other, and the two are then tied together. This is a simple method, but causes a little puckering. C. Shows a useful method that may be employed to obviate this puckering. In passing the needle through the skin for the last time it is made to go in the opposite direction, *i.e.* in the diagram from left to right, whereas the rest of the stitch is made from right to left. The free end shown on the left-hand side of the incision is then held in one hand while traction is made upon the needle with the other ; the result is that the last loop is drawn tight and the wound is closed. The free end on the one side and the loop—or the two free ends if the needle be cut off—on the other are then tied together. This is a very simple and effective plan.

of medium thickness, as the fine thread cuts out very quickly under these circumstances. This suture can also be made with horsehair or silkworm-gut ; the strands of the latter are, however, only about fourteen inches long, and several must be used for a long incision. They are non-absorbent, and are therefore very useful in septic wounds.

Removal of Sutures.—Button sutures should be removed in about five or six days. When there are also silver ' relaxation stitches,' and the wound is dressed for the purpose of removing the buttons, the continuous silk suture uniting the edges of the wound can as a rule be taken out at the same time, only the deep silver stitches being left. The period at which these latter should be removed must depend on the firmness of union between the edges ; generally they can all be taken out at the end of a week or ten days. If there be any point where the strength of the union is doubtful—as for instance where a triangular flap of skin has been dragged up to meet two other flaps—the stitches at the apex of the flap should be left in place for a fortnight. Unless button sutures have been used, there is no necessity to dress the wound for the purpose of removing

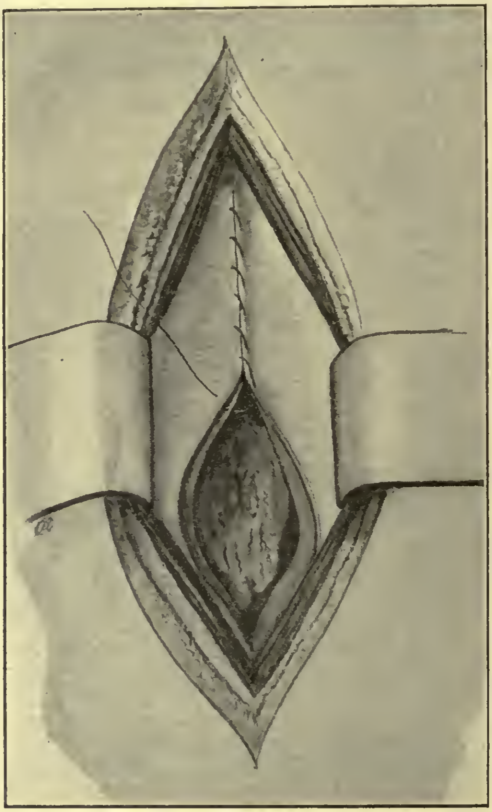


Fig. 45.—Suture of an Abdominal Wound in Four Layers.—*First layer.* The peritoneum and the posterior layer of the sheath of the rectus are united by a continuous 'glover's' suture of catgut; at the lower part of the incision the omentum is shown drawn down over the abdominal viscera.

any stitch before firm union has occurred; we seldom change the dressing until the tenth day after the operation, unless button sutures have been employed.

Avoidance of Movement.—This should be provided for in all wounds. In operations on the extremities, a suitable splint must be applied to control the movements of the neighbouring joints, and this should be kept on for about a week or ten days. In operations upon the abdomen, a firm binder will usually ensure rest, if the patient be forbidden to sit up. In operations about the neck, it is usual to put on an extra amount of dressing, which is firmly fixed with a bandage, so that, when the deeper part becomes stiffened by the dried blood, and is supported by the large mass of dressing outside it, it practically forms a splint for the head and neck; some surgeons employ a specially moulded splint of

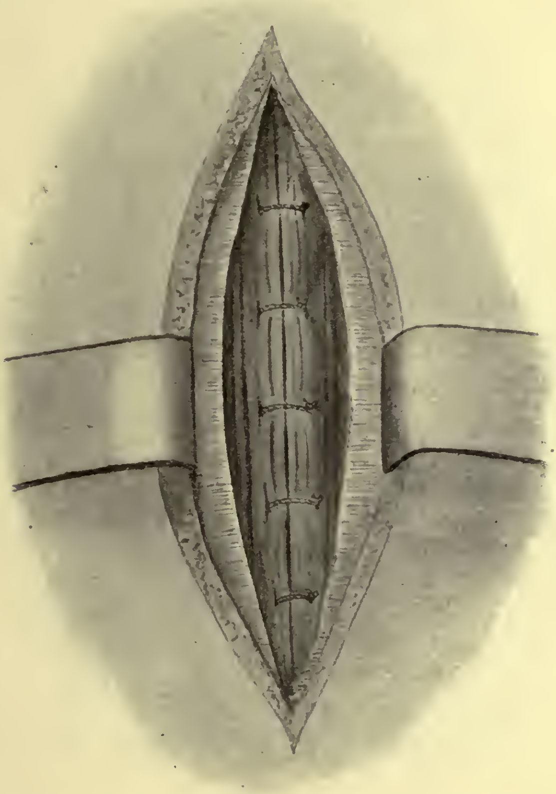


FIG. 46.—SUTURE OF AN ABDOMINAL WOUND IN FOUR LAYERS.—*Second layer.* The abdominal muscles have been drawn together by a series of interrupted sutures inserted at right angles to the direction of the muscular fibres.

poroplastic material or guttapercha, but this is rarely necessary except in young children.

Avoidance of Irritation.—Care must also be taken to prevent irritation of the wound by antiseptic solutions or dressings; but if a wound be not dressed until it has healed, as is our usual rule, there will of course be no irritation resulting from antiseptic lotions. The chief point of importance, therefore, centres in the choice of the dressings, which must not exert any chemical or mechanical irritation. Care must be taken to see that the gauze placed next the wound does not contain any soluble irritating antiseptic substance; the mere presence of the gauze over a wound, the edges of which have been brought together

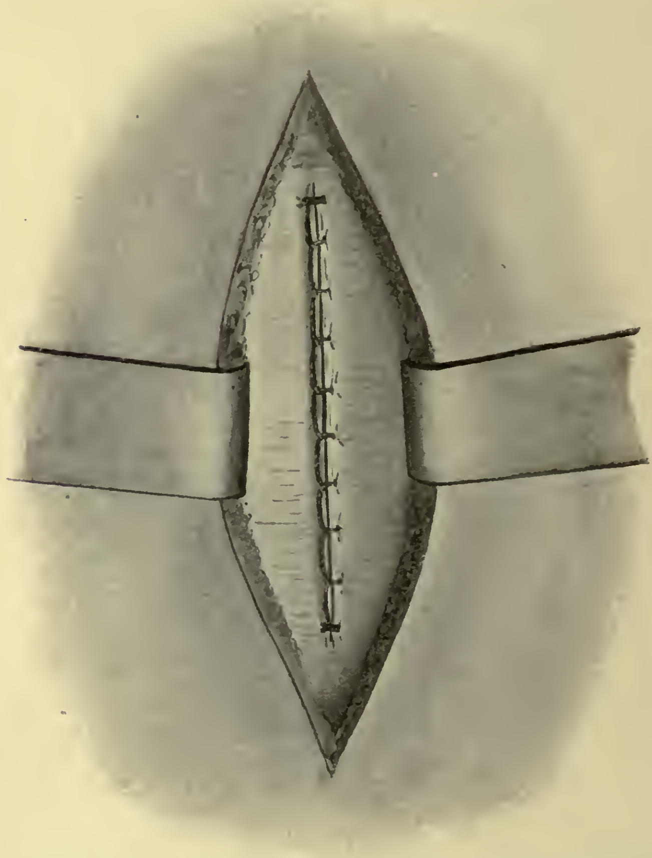


FIG. 47.—SUTURE OF AN ABDOMINAL WOUND IN FOUR LAYERS.—*Third layer.* The anterior layer of the sheath of the rectus is closed by a continuous suture of fine silk.

accurately, does not interfere with healing by first intention, particularly if the wound be left undisturbed for a week or ten days. When silver stitches are used, their ends are prone to become entangled in the gauze, and any movements of the patient may drag upon them; this can be avoided by interposing, between the line of incision and the gauze dressing, a narrow strip of sterilised Lister's protective oiled silk (see p. 51), thin sheet rubber, or tinfoil. When button stitches are used, each button should also be covered with a piece of this material, but care must be taken that the dressing overlaps the latter for a considerable distance in all directions ; if not, sepsis may spread in beneath it.

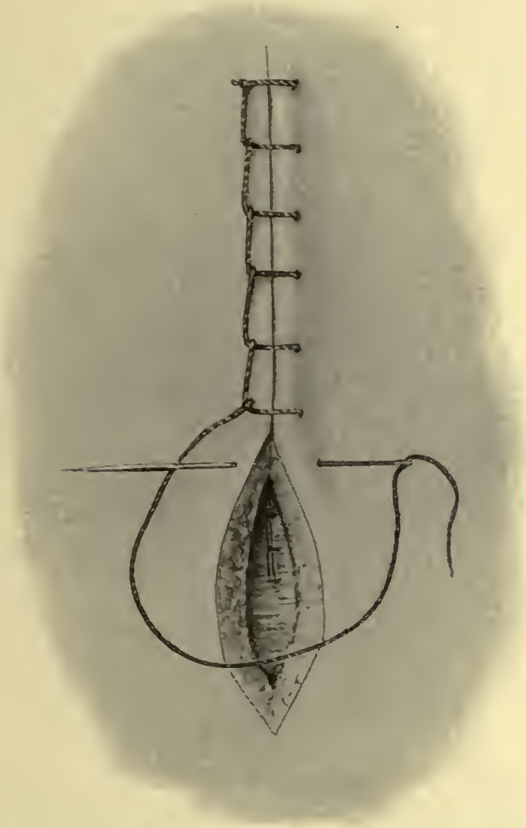


FIG. 48.—SUTURE OF AN ABDOMINAL WOUND IN FOUR LAYERS.—*Fourth layer.* The incision in the skin is being closed by a continuous silk suture.

Drainage.—After the operation has been performed, the question of drainage arises. When Lord Lister began his antiseptic work he laid great stress on the use of drainage ; at that time one of the results of the free application of carbolic acid to wounds was a marked exudation of serum, which, if not allowed to escape, distended the wound and sometimes caused considerable trouble in healing. But with the introduction of sublimate solution and the avoidance of carbolic acid in the wound, the conditions underwent a change, and at the present time it is only comparatively seldom that drainage is required. In order to dispense with drainage safely it is essential to arrest all bleeding before the wound is closed, and then to bring the deeper parts of it into apposition so that there shall be no 'dead space' into which bleeding may take place subse-

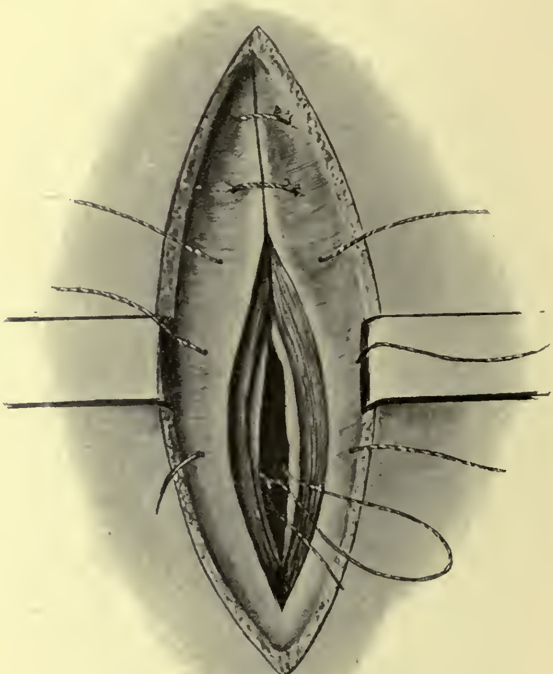


Fig. 49.—Suture of the Abdominal Wall in Two Layers.—All the structures from the peritoneum to the superficial layer of the sheath of the rectus are drawn together by stout silk sutures; the skin is then closed with a silk suture as in Fig. 48.

quently. This may be done in some cases by buried sutures (see p. 137), as, for instance, after laparotomy (the most suitable form of stitch for which is shown in Figs. 45–50), exposure of the kidney, etc.; but in ordinary cases we consider that efficient pressure applied outside the wound suffices. It is only in certain cases of incised wounds made by the surgeon that it is impossible to obliterate any cavity in the wound; in them, drainage tubes are required.

Cases calling for Drainage.—The following are the chief conditions in which drainage seems desirable :

(1) *In amputation wounds.*—After amputation it would not do to keep the flaps firmly pressed together for fear of interfering with their blood-supply, while it would be equally hurtful to allow blood to distend them, and possibly lead to gangrene. Therefore it seems advisable to introduce a drainage-tube in all cases of amputation.

(2) *When a cavity is left.*—For example, after excision of one-half of the thyroid gland a cavity is left into which bleeding is very apt to occur, for pressure cannot be applied satisfactorily without interfering with the trachea ; in these and similar cases the

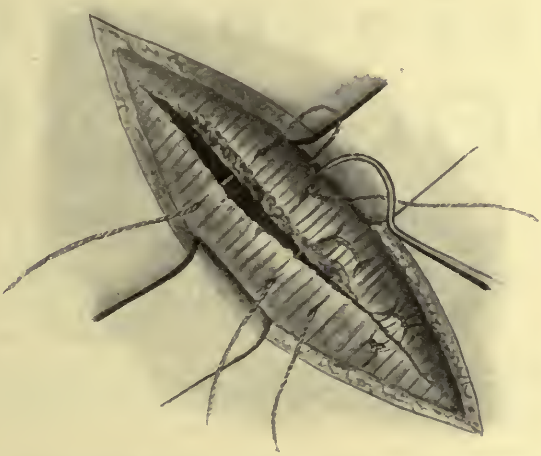


FIG. 50.—SUTURE OF MUSCLES BY THE MATTRESS STITCH.—This suture is used when the muscular fibres have been divided transversely.

temporary use of a drainage-tube is advisable. A drainage-tube is also of service when the wound is very extensive, as after removal of the breast for cancer.

(3) *When there is oozing which cannot be stopped by ligature—e.g.* in abdominal operations, where a large number of adhesions have been broken down and there is a definite liability to the formation of a hæmatoma.

(4) *In very fat people.*—Wounds in very stout people seem to fill with oil, and this apparently interferes with the proper healing of the wound ; in these cases also it is well to employ drainage.

(5) *When there is a risk of sepsis.*—Drainage should always be employed when a sinus or ulcer is present at the seat of operation, and also in compound fractures, lest the attempt to disinfect them prove unsuccessful.

When a drainage-tube is introduced it need not extend the whole length of the wound so long as it passes into the deeper parts of it; and it is well, in order to avoid the risk of displacement of the tube, to stitch the outer end to the edges of the skin after cutting the tube flush with the surface. Drainage-tubes need not be left in a wound longer than three or four days unless sepsis occurs. If it be desired to leave a particularly small scar, a few strands of horsehair will suffice to form a fine capillary drain.

Drainage should be carried out by means of tubes; the gauze wicks which are so much used at the present time are objectionable and inefficient.

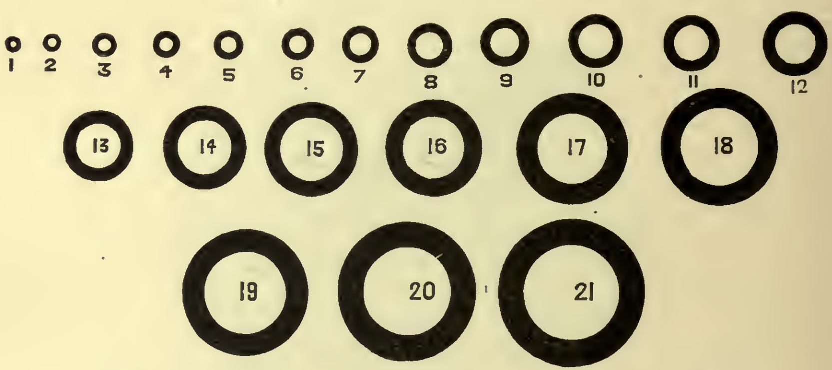


FIG. 51.—SIZES OF DRAINAGE-TUBES.—There is no standard gauge for these, each instrument-maker numbering them independently. The numbers quoted in this book refer to drainage tubes whose cross-section is represented in this figure.

Dressings.—After having completed the operation, stitched up the wound, and arranged for drainage if necessary, the next point is the application of the dressings. Before the dressings are applied, the blood should be squeezed out of and removed from the neighbourhood of the wound, care being taken to wash away from the wound and not towards it. During this process, it is well to protect the wound from infection by means of a piece of cyanide gauze soaked in 1 in 2000 sublimate solution, which is removed just before the dressing is applied. At the present time the tendency is to use dry dressings, which possess two great advantages. In the first place, the blood dries quickly in them, and does not therefore form a suitable soil for the development of organisms; and consequently, if the dressings be not quite aseptic or, the skin be not completely disinfected, the organisms may be unable to grow and reach the wound. In the second place, the dried-up blood-stained dressings adhere to the skin and form a sort of splint, which keeps the edges of the wound at rest.

Lister's Cyanide Gauze.—The most universally applicable and most satisfactory dressing yet introduced is the latest dressing proposed by Lord Lister—viz. gauze impregnated with the double cyanide of mercury and zinc. Certain precautions must be taken in using this dressing. As it comes from shops it is not sterile, and must be disinfected before use (see p. 97). Even when it has been sterilised in an autoclave it is well to moisten the layers applied next to the skin with 1 in 60 or 1 in 40 carbolic acid or 1 in 2000 perchloride of mercury solution, for two reasons: in the first place, the wet gauze absorbs the blood better and diffuses it more evenly through the dressing; while, in the second place, the double cyanide dissolves so slowly in the blood that dust falling upon the wound may have time to infect it before the cyanide has had time to become dissolved by the blood, especially if a drainage-tube has been used. Outside the gauze we apply either salicylic or cyanide wool, sterilised in an autoclave if possible; large quantities are used, and a wide area of skin all around the wound should be covered. Besides being extensive in area, the dressing should be of considerable thickness, some twelve to twenty folds of gauze being employed.

Pressure.—After applying the first few folds of gauze, it is well, in some cases—*e.g.* operations for hernia—to place over the wound sterile sponges wrung out of the antiseptic, so as to approximate the deeper parts and prevent the formation of a cavity. Outside the sponges more gauze is applied, and outside this again a mass of sterilised salicylic or cyanide wool. Salicylic wool does not absorb well, and the object in employing it is not so much to furnish an additional antiseptic layer (though that is an important point) as to provide a material which, while permitting evaporation, leads to a diffusion of blood and serum over a considerable area of the cyanide dressings. As a matter of fact, however, the discharge from the wound is usually slight when sponge pressure is employed, and seldom reaches the wool at all. Bandages are applied outside the wool, specially firm pressure being brought to bear over the sponges.

When to change Dressings.—A dressing of this kind is usually left undisturbed for about ten days, unless there be some reason for changing it, such as discomfort, fever, the presence of a drainage tube, or any suspicion of sepsis. It is a mistake to change a dressing soon after the operation unless it be really necessary, because the dressing adheres to the skin, and, in pulling it off, the union of the deeper parts may be disturbed, and bleeding may even occur into them. The following are the principal cases in which an early change of dressing is called for:

(1) In some cases, the dressings become hard and uncomfortable as they dry, and in sensitive patients therefore it may be advisable to change them at the end of three or four days; the second dressing never becomes so hard and uncomfortable as the first.

(2) When the amount of oozing from the wound is excessive. The old rule that dressings required changing very soon after discharge showed itself through them is not now applicable; as a matter of fact, it is not uncommon for a little blood to appear on the outer surface of a dressing such as that described above within a few hours after the operation; but this dries up quickly and does not form a suitable medium for the growth of bacteria, because the double cyanide salt is a powerful inhibitory agent, and, being only slightly soluble, is not washed out by the first blood which passes through the dressing. All that is necessary is to wet the soiled portion with 1 in 20 carbolic solution, to apply fresh wool outside this, and to secure it by another bandage.

(3) When a drainage-tube has been inserted, the dressings must be changed at the end of two or three days in order to remove it; if the wound be large, the discharge through the tube may be sufficiently copious to necessitate a change of dressing at the end of twenty-four or forty-eight hours.

(4) If the temperature rise and remain over 100° F. for more than twenty-four hours after the operation, or if there be much pain, the dressing must be removed to see if anything be wrong with the wound.

How to change Dressings.—When the dressings are changed at the end of about ten days, the wound is usually soundly healed; the stitches are then taken out, and a small piece of gauze or salicylic wool is fixed over the line of incision for a few days by means of collodion. In changing dressings it is well to employ a 1 in 2000 sublimate solution to wash the wound, except in operations in the axilla, the perineum, or about the pubes, etc., where, on account of the proximity of hairy parts, it is advisable to wash the skin around the wound with a 1 in 20 carbolic lotion. The region of the wound should be surrounded by towels wrung out of an antiseptic solution, so that the bedclothes cannot come into contact with the wound, the instruments, or the surgeon's hands. The latter are disinfected as for an operation (see p. 101). The wound should be swabbed over gently, but thoroughly, with the antiseptic solution. Should the wound be not quite healed, or should it seem advisable to leave any of the stitches in place for some time longer on account of tension upon the edges, a dressing may be applied similar to that put on immediately after operation (see p. 150), the only difference being that the sponges need not be employed. In breast cases, for instance, where a large amount of skin has been taken away, it is often advisable to change the first dressing before the end of the first week, in order to remove some of the stitches; the remaining stitches may then be left for another week.

After-progress of the Wound.—It will be found that neither local nor constitutional disturbance follows operations conducted with the precautions recommended above. After a very severe operation, the temperature is at first sub-normal, the patient suffers from a certain amount of shock for some hours, and this is followed, to an extent closely corresponding to the degree of shock, by a certain amount of reaction, so that next day the temperature may rise to 100° or even to 101° F. At the same time, however, the pain complained of immediately after the operation subsides, and there is no fresh development of it, as would be the case were the temperature due to sepsis. In the course of another twelve to twenty-four hours the temperature falls rapidly to normal.

Treatment without Antiseptics.—The other plan, to which we have already referred (see p. 99), in which attempts are made to keep wounds aseptic without the use of antiseptic lotions and dressings, does not yield in practice the uniformly good results which are obtained by the method just described. In it the use of antiseptics is entirely avoided during the actual performance of the operation, and in the after-treatment of the wound. The skin is purified, and the hands of the assistants and the operator are disinfected much in the manner already described (see p. 150). The instruments are boiled, but are not afterwards immersed in antiseptics, and no antiseptic solution is at hand in which to rinse the hands or the sponges. The sponging of the wound is done with pieces of wool or gauze disinfected by heat and used dry, and the towels placed around the operation area are also dry, and have been previously disinfected by heat. There is therefore no possibility of correcting any accident that may happen during the operation, such as dust falling on the towels, or the unobserved contact of the hand with any object that has not been disinfected. The dressings consist for the most part of simple absorbent unmedicated gauze and wool which have been disinfected by heat, the drum or bag in which they have been disinfected being opened at the side of the patient by the surgeon himself. It is obvious that the greatest care is required in handling these if accidental contamination is to be avoided. In the Listerian plan, which we recommend, any such accidental contamination may be automatically remedied if it should occur, because everything is being frequently soaked in an antiseptic solution ; in the so-called 'aseptic' plan there is no corrective for these accidents at all, and, consequently, experience shows that the results obtained by its means are inferior to those obtained by the other method.

There is no doubt that in theory it ought to be possible to carry out this aseptic plan, and if it were found in practice that the use of antiseptics gave rise to great irritation in wounds, the employment of such a cumbrous and troublesome method as this would be justified. As a matter of fact, however, the irritation of wounds from such antiseptics as we recommend is inappreciable, and there is no reason for making use of this troublesome method, particularly as the results obtained by it are not so good as that obtained by using antiseptics. The aseptic method can only be carried out by a skilled and experienced bacteriologist, with all the resources of a large and well-equipped hospital at his command. In private practice, it is almost impossible to carry it out in all its details; moreover, it may prove positively harmful, since a single error may invalidate the whole proceeding, and no corrective is possible. Prolonged experience of the Listerian methods has failed to convince us of any danger in or objection to their use.

Causes of Failure to secure Healing by First Intention.—When all the steps of the antiseptic method have been rigidly adhered to, healing by first intention almost invariably follows. When it does not occur, it is generally because some error has been committed in the management of the case, which has led to the occurrence of sepsis. Sometimes, however, union may fail, at any rate in part, notwithstanding that the wound remains aseptic. The most common cause of this is the *accumulation of serum* in the deeper parts of the wound; in these cases a drainage-tube should have been employed. If accumulation does take place, it is better to evacuate the serum at once than to wait in the hope that it will be absorbed; doubtless absorption sometimes occurs, but in the majority of cases the serum will find its way out along the line of incision. When, therefore, a collection of fluid in the wound is found at the first dressing, time is saved by opening up the incision with a pair of sinus forceps, letting out the fluid and introducing a small drainage-tube, which should be left in for two or three days. The fluid is serum or altered blood, and the wound closes quickly when a drainage-tube is introduced and pressure applied outside.

The importance of putting in enough sutures to prevent gaping of a wound, and of not tying them too tightly, has already been referred to (see p. 142). If too few sutures have been employed, the tension on any individual stitch may be so great that it will cut its way through the skin and allow a portion of the wound to gape. *Movement* of the part may also interfere with primary union. In other instances the cause of non-union may be that the knife has been held obliquely in making the skin incision; the bevelled edge of skin thus left on one side often dies. In the majority of cases, however, when union fails, it is owing to the presence of *sepsis*; and if suppuration occur in a wound made by the surgeon through unbroken skin, its occurrence must be ascribed to errors in carrying out the antiseptic technique and not to the method itself. Whether it be that the surgeon has used impure materials for his ligatures or stitches, or whether, as is commonly the case, he or his assistants have introduced the organisms with their hands, the cause of failure is the same. This fact cannot be too widely appreciated.

Errors which may be made in carrying out the antiseptic treatment of wounds have already been described, but it is impossible to point out all the extraordinary mistakes which are committed daily. Unless the surgeon constantly bears in mind the fact that nothing that has not been made aseptic must come in contact either with the wound, the instruments, or the hands that are introduced into the wound, he will be sure to go wrong eventually. A preliminary bacteriological training is of incalculable advantage, for with it the manipulations necessary to secure asepsis become automatic, and the surgeon is thus enabled to concentrate his undivided attention upon the operation.

Treatment when Sepsis occurs.—The onset of sepsis is indicated by pain and throbbing in the wound. The reactionary temperature commonly met with after severe aseptic operations, instead of falling in from twenty-four to thirty-six hours, continues to rise, and all the symptoms of pyrexia set in. When this febrile condition has set in, the wound should be examined at once, and if red, tender, or swollen, should be opened up and proper drainage provided. The degree to which the wound should be opened up must be judged separately for each case, as it frequently happens that the suppuration is due to an organism of low virulence, and the removal of a stitch, followed by the insertion of a small drainage-tube at the most dependent part of the wound will suffice to meet all the requirements of the case. It would be a mistake to lay open the entire wound because there is slight infection at one point.

As a rule it is not advisable to wash out a wound in this condition, although this is done by some surgeons. Washing out a septic wound with antiseptics will not arrest the infection, and it can only irritate and damage the inflamed tissues, and possibly precipitate the entrance of micro-organisms into the system. Provided there be a free exit for pus, it is best not to wash out, squeeze or irritate the wound in any way. The only exception to this rule is in large cavities, when there is reason to believe that the symptoms are mainly due to septic intoxication—that is to say, absorption of poisonous chemical products, and not true general bacterial infection. Under such circumstances it is well to wash away the septic fluid in the wound with sterilised saline solution or with a solution of peroxide of hydrogen (10 vols.). This is not done with the view of killing bacteria, but of removing the poisonous chemical products which are being absorbed, and are producing the symptoms. It is well to go on with the antiseptic dressings already described (see p. 150); they should be changed once daily, or oftener, but there is no need to continue the irrigation after all the decomposing blood-clot has been washed away.

When no general infection has occurred, or is about to take place, the temperature falls, and the other general and local conditions improve within a few hours after a free exit has been provided for the discharge. In the course of a few days suppuration ceases and the discharge becomes serous; if everything goes well, the drainage-tube may be left out in from ten to fourteen days. When, on the other hand, the temperature keeps up and the other symptoms continue, the suspicion is aroused either that there is some recess in the wound from which the discharge is not escaping properly, or that some general infection is occurring. In either case the wound must be opened up freely and cleansed and all recesses must be exposed. When retention of the discharge is not sufficient to account for the general symptoms, the wound should be sponged out with undiluted carbolic acid. In some cases the surgeon may even venture to scrape away the granulation-tissue with a sharp spoon, but in doing this there is always a certain risk of forcing organisms into the circulation. One of Barker's flushing spoons (see Fig. 52) should be employed, the fluid used for irrigation being a 1 in 4000 sublimate solution; when the scraping is complete, liquefied carbolic acid is swabbed over the entire surface of the wound. After this has been done, the wound should be packed with cyanide gauze and made to heal by granulation from the bottom, the packing being renewed once or twice daily if the suppuration persist. If this procedure be followed by a fall in the temperature and an amelioration of the general symptoms, it may be possible to discontinue the packing in three or

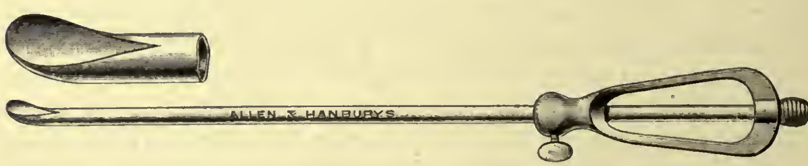


Fig. 52.—Flushing Curette.—The handle of the curette is provided with a thumb-screw so that it can be moved along the instrument, and give greater purchase if required. In the small upper figure the sharp end of the curette is shown full size.

four days and to stitch up the edges of the wound again after introducing a drainage-tube.

When the occurrence of rigors and sudden elevations of temperature lead one to suspect pyæmia, it is important to look carefully for any thrombosed veins when opening up the wound; and should any be found, the main vein above the thrombosed area should be ligatured, and a portion excised in order to cut off the local source of infection from the general circulation. When the constitutional symptoms persist in spite of this energetic local treatment, nothing remains but to treat the patient on the lines recommended for pyæmia (see p. 193). When there is diffuse cellulitis around the wound, constant irrigation (see p. 32) may be employed, to wash away the septic material as soon as it is formed. Incisions into the inflamed area may be necessary (see p. 31).

When the wound has become covered with healthy granulations, the healing process can often be accelerated by secondary suture. Strong silkworm-gut stitches should be passed deeply into the tissues on either side of the wound and should be tied firmly, but not too tightly; a space should be left between the stitches at one end of the incision for a drainage-tube. Such a suture as this necessarily involves less free drainage than before, and for a day or two afterwards there may be slight rises of temperature.

Treatment of Wounds in which the Edges are not brought together.—It is important that organisms should be excluded from these wounds also, and if this be successfully accomplished, and the part kept absolutely at rest and not irritated by the dressings, the space between the edges fills up with blood, and healing by blood-clot will occur. To obtain this result, similar methods and dressings should be employed to those used when the edges have been brought together, but, in order to protect the blood-clot from the irritation of the dressings, a piece of Lister's oiled silk protective or thin sterilised rubber or tinfoil, somewhat larger than the wound, should be interposed; outside this a large gauze and wool dressing is applied. When the wound is large, healing by blood-clot generally occurs to a considerable extent, and then a small part in the centre undergoes a certain amount of granulation before complete cicatrisation takes place.

Thiersch's Skin-grafting in Fresh Wounds.—Since healing by blood-clot is a slow process, and is always open to the risk of accidental contamination of the wound, Thiersch's skin-grafting is often employed, as it is a quicker method of obtaining healing. If it be carried out immediately at the end of the operation in which the wound has been made, a good result will be obtained in most cases, and healing will occur almost as rapidly as in union by first intention, while the contraction which follows granulation will be avoided almost entirely. The process is identical with that described on p. 53, except that the grafts are applied direct to the fresh surface of the wound, which does not require to be scraped. When the operation has been very extensive, and the patient is very collapsed, it may be advisable to defer the skin-grafting for a short time; in these cases the blood-clot is removed from the surface of the wound after about ten days, and, when the oozing has been arrested, the grafts are applied in the usual manner. It might be supposed that grafts would not adhere well to non-granulating tissues, but they do; and immediate skin-grafting is a very valuable help in obtaining a good result where so much skin has to be removed that a large open wound would otherwise be left.

Plastic Operations.—Where the cutaneous loss is not excessive, and the skin in the neighbourhood is fairly lax, the interval between the edges of the wound may be obliterated by means of a plastic operation, which is an operation performed with the view of covering in some congenital or acquired defect in the skin or mucous membrane. Here we shall only deal with the covering-in of defects left after an operation in which the edges of the wound cannot be brought together. The plastic operations in connection with other affections will be dealt with in connection with those affections.

In such a simple form of defect as an **oval wound**, the steps necessary to bring the edges into apposition are generally very simple. If the skin around the wound be undercut widely enough to allow the elasticity of the skin sufficient play, a very extensive defect may be repaired thus. In removal of the breast, for example, an oval gap measuring six inches or more in its transverse diameter may be closed by undermining the surrounding skin.

The best way is to proceed as follows. In small wounds, the knife is carried between the superficial fat and the deep fascia ; in large ones, it should be swept between the deep fascia and the muscle. By this means the skin and fascia are raised from the deeper parts for such a distance around the wound as the surgeon judges will be necessary to allow the edges to come together. The undermining should be most extensive opposite the shorter diameter of the oval, and should be carried on until the edges of the wound can be brought easily into contact by pulling upon them. In raising these flaps care must be taken to direct the edge of the knife towards the deeper parts and not towards the skin ; failure to observe this precaution is apt to result in scoring of the flap, and, as the blood-vessels which supply the skin ramify in the subcutaneous fat, the blood-supply to the edges of the wound might be cut off and sloughing might ensue.

The undermining must be free enough to allow the edges of the wound to come together without such tension as to endanger the circulation in the flaps. Flaps that have been dragged together after insufficiently free undercutting will become white on putting in the stitches, and the circulation in them will not be restored ; in such a case, therefore, it will be necessary to carry the undermining further, so as to allow of the flaps being brought together without being permanently blanched. If at first there be a little whiteness in the immediate vicinity of the stitch, it will disappear in a few minutes when the tension is not too great. Deep stitches and, if necessary, button stitches should be used to relax the edges in order that there may be no tension upon the actual line of union (see p. 139).

Angular, quadrilateral, or irregular-shaped wounds require one of the plastic operations proper for their closure. A small quadrilateral defect is easily closed by making straight incisions which extend two corresponding sides of the parallelogram into the healthy skin on one side ; for example, in Fig. 53 the side *AB* is extended to *b* and *CD* to *d*. The flap *BDdb*, which ought to be about double the length of the side *AB*, is then dissected up along with the subcutaneous tissue ; the elasticity of the skin then allows the flap to be stretched with comparatively slight tension, so that the point *B* may be stitched to the point *A*, and the point *D* to the point *C*.

When the quadrilateral defect is large, it can be closed by making similar incisions on the opposite side also ; for example, in Fig. 53, by extending the side *AB* both to *b* and to *a*, and *CD* to both *d* and *c*. The two flaps, *ACca* and *BDdb*, are dissected up and can be made to meet in the middle of the defect.

Where the defect is triangular, say an equilateral triangle, and the raw area is small, it may suffice to make an incision which prolongs one side only, the extension being about double the length of that side (see Fig. 54). The triangular flap thus marked out is dissected up along with the fat, when the point *B* can generally be stitched to the point *A*. If, however, the defect be large, the sides may be made to meet by forming a second similar flap on the other side—that is to say, by extending one side in both directions. These two flaps will then meet in the middle line and can be sewn together (see Fig. 54).

In many cases, however, especially when the triangular space is large,

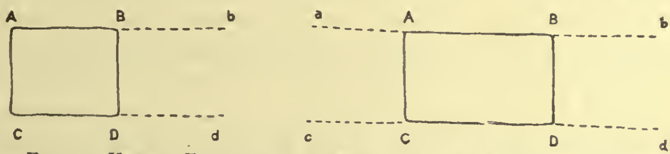


FIG. 53.—HOW TO FILL A QUADRILATERAL DEFECT BY MEANS OF A PLASTIC OPERATION.—The details are given in the text. On the left-hand side is shown the method of filling a small defect, on the right-hand side, a large one.

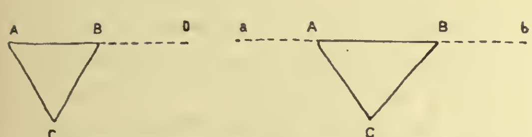


FIG. 54.—HOW TO FILL IN A TRIANGULAR DEFECT BY MEANS OF PLASTIC OPERATION.—The steps of the operation are given in the text.

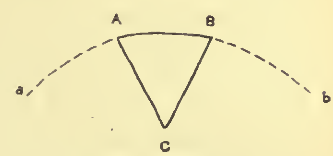


FIG. 55.—HOW TO FILL IN A TRIANGULAR DEFECT BY MEANS OF CURVED INCISIONS.—The dotted lines represent the curved incisions.

the incisions for the flaps should be *curved*, and, in the case of irregular defects much better results will be obtained by the use of curved incisions than by straight ones. When it is necessary to remove the lower lip, this is usually done by taking out a V-shaped piece, the apex of the V being towards the chin. To fill up the gap thus made, a large curved incision should be made, beginning at the angle of the mouth, running down over the jaw on to the neck, and curving inwards towards the upper part of the larynx. When the whole lip has been removed, a similar incision is made on each side. The incision goes through the whole thickness of the cheek; when it passes on to the neck, the skin and superficial fascia alone are dissected up. When the flaps have been raised sufficiently, the curved incisions allow them to slide inwards, so that the two sides of the triangular defect meet in a vertical line, and may be stitched together; a few points of suture are then put in along the curved lines of incision (see Fig. 55).

We need not here go into detail as to the covering-in of irregular defects, or of those in special situations; they are dealt with in their appropriate places. The principle to which we wish to call attention is that, when the surgeon has to make good large defects of skin, curved incisions will enable him to do so with much greater ease and less extensive dissection than if straight incisions alone were employed.

Use of Granulating Flaps.—When the defect is large and the flaps to be turned in are long and have a comparatively narrow base—in other words, when the blood-supply must necessarily be imperfect—it has been recommended that the flap should be dissected up but left attached at each end, and that both it and the wound should be allowed to granulate before the actual transplantation of the flap takes place. The reason for this is that the flap is more likely to retain its vitality if it be made in this manner, while new blood-vessels and a more ample blood-supply are developed during the process of granulation.

The flaps are usually rectangular, and their two ends are not detached. Parallel incisions are made down to the deep fascia, and then the flap is undermined throughout its whole extent, so that the finger can be passed under it in all directions. A piece of sterilised protective, sheet rubber or tinfoil is then inserted between the under surface of the flap and the deeper structures, and this is kept in place for ten days, when the new vascular supply will have developed; one end of the flap is then divided, and the latter turned in so as to cover the defect. This method certainly overcomes great difficulties with regard to the nutrition of the flaps, but cases in which such elaborate measures are necessary are usually more successfully treated by Thiersch's skin-grafting.

Occurrence of Sepsis in Open Wounds.—Should these wounds become septic, the results are not usually very serious, unless the wound communicates with a cavity in the bone or with the interior of a joint, etc.; the wound is widely open, and therefore the septic material readily flows away into the dressing, and only a small amount of the toxins is absorbed. Nevertheless, if the wound be large, the temperature rises at first, and a varying degree of traumatic fever occurs, while the edges of the wound become swollen, red, and painful, and in the course of two or three days its surface becomes covered with a layer of granulation-tissue.

Treatment.—As soon as it is thought, from the rise of temperature and other symptoms, that sepsis has occurred, the dressings should be removed, the surface of the wound thoroughly cleansed, and any adherent blood-clot removed. When the symptoms are not severe, the cyanide dressings may be continued, but they should be changed daily, and the surface of the wound should be washed with a 1 in 2000 sublimate solution. If there be much inflammation, it will be well to put a layer of mackintosh outside the wet cyanide dressings, so as to keep them moist, and to change the dressing night and morning. Carbolic lotion should not be applied to the surface of these wounds, especially in the early period, because it injures the vitality of the granulation-cells, and thus interferes with their power of destroying the virulent organisms on the surface; moreover, granulating wounds treated with carbolic acid absorb much more readily than when treated in other ways.

When the discharge is foul, *iodoform* is often useful. This drug is not to be recommended as an antiseptic for a freshly made wound when the surgeon is able to take all the precautions necessary to prevent the entrance of micro-organisms, but when applied to a putrefying sore it does exert antiseptic properties; it then seems to break up the toxins, and in doing so becomes decomposed itself and free iodine is liberated. Hence, by destroying the products of the bacteria in septic wounds, the drug takes away their weapons, so to speak, while at the same time the iodine liberated inhibits the growth of the bacteria or may even destroy them. Iodoform should always be disinfected beforehand by immersing it in a 1 in 20 carbolic acid solution for several days, straining it through sterilised muslin, and then drying it in a jar to which bacteria cannot gain access.

When granulation is complete and the febrile condition has passed off, mild antiseptic dressings, such as antiseptic ointments, or the boric lint and protective dressing (see p. 51), may be employed. The ung. borici or ung. eucalypti is the most suitable ointment to use; the former should be of the full pharmacopœial strength at first, but when healing is commencing, half-strength should be substituted, because the full-strength ointment seems to be too irritating for the young epithelial cells, and prevents the cicatrisation of the wound. If the wound be large, skin-grafting may be employed in about a fortnight; the procedure is similar to that for grafting an ulcer (see p. 52).

TREATMENT OF WOUNDS THAT CANNOT BE KEPT ASEPTIC.

Wounds made by the surgeon which not only involve the skin, but communicate with one of the mucous canals or with a septic cavity, cannot be kept aseptic. It is impossible, for example, to exclude bacteria from a wound in the mouth, seeing that they are everywhere present in the fluids on the surface of the mucous membrane. The problem, therefore, is not how to exclude them, but how to minimise their deleterious action.

Wounds of Mucous Membranes.—In the first place, it is important that the manipulations during the operation should be gentle; in other words, the vitality of the tissues must be interfered with as little as possible. Union by first intention is not always obtained in wounds involving the mucous membranes, but is often highly desirable, especially in such operations as staphylorrhaphy, etc. In order to obtain primary union in these cases the bleeding must be arrested completely, and care must be taken that no foreign material is left between the edges of the wound ; moreover, the whole of the cut surface, and not merely the edge of the mucous membrane, must be in accurate and close apposition. In wounds of mucous membranes healing by blood-clot will not take place. The best material for stitches in these cases is either silkworm-gut, or horsehair when a finer stitch is wanted ; silk should not be used, as it is absorbent and will retain decomposing material. No dressing applied to the wound is likely to be of any real service, but it is well to wash the surface of the mucous membrane frequently with weak antiseptic solutions, such as permanganate of potash (two grains to the ounce), or sanitas (a teaspoonful to the tumbler of water). The more irritating antiseptics, such as carbolic acid, should not be employed.

When the edges of the wound have not been brought together, and when, therefore, healing by granulation must take place, it is of great importance to avoid septic decomposition on the surface of the wound during the first two or three days ; at the end of that time, there is usually such a marked invasion of cells in the wound that bacteria find considerable difficulty in entering. Almost the only bacteria that are able to penetrate at a later period than this are streptococci or diphtheria organisms. In order to keep these sores aseptic for the first few days, Lord Lister used to sponge over the surface of the wound with a solution of **chloride of zinc** (forty grains to the ounce), after the bleeding had been arrested. He regarded it as, so to speak, pickling the surface of the wound for a day or two after it had been made ; after a thorough application of chloride of zinc to a cut surface exposed to the elements of putrefaction, decomposition certainly does not seem to occur so early as when the wound is left to nature, and therefore this method is one which may be strongly recommended. In these cases also **iodoform** is much used ; the cut surface may be lightly powdered with iodoform crystals after having been sponged with the chloride of zinc solution. Iodoform must not be used too lavishly for wounds of the mouth, however, as the drug may be swallowed, and symptoms of iodoform poisoning may appear.

As soon as the wound is granulating, mild antiseptic washes, such as weak sanitas (about a teaspoonful to a tumbler of water), permanganate of potash (one or two grains to the ounce), or boric acid (ten grains to the ounce) may be used. If the granulations become prominent, an occasional application of solid nitrate of silver or sulphate of copper will keep them down.

When the wound involves both skin and mucous membrane—as, for example, a wound of the cheek—the skin-wound should be stitched up accurately with interrupted sutures of silkworm-gut, but the wound on the mucous surface should be painted over with chloride of zinc solution, and only brought together here and there with a few catgut sutures. A piece of gauze wet with a 1 in 2000 sublimate solution should be laid over the skin incision for a few hours, until the bleeding has ceased, when half-strength boric ointment and boric lint may be substituted, or the wound may be left uncovered and a scab allowed to form. When there is a pocket in the cellular tissue communicating with a mucous surface—as, for example, after operations upon the floor of the mouth and the glands in the neck—a large drainage-tube must be inserted at the lowest point of the wound, so as to prevent accumulation. In three or four days this should be replaced by one of smaller calibre, which should be cleaned and sterilised by boiling at every dressing night and morning. The drainage-tube can rarely be dispensed with before the third week.

An **antistreptococcic serum** has been introduced for use in cases of streptococcic infection, which is the most serious and most common form of infection in operations on mucous membranes, especially about the mouth. This serum has been used in a good many cases as a prophylactic measure before the operation with the object of protecting the body for a time against streptococcic invasion, so that the healing of the wound shall be undisturbed by the action of these organisms. When used for this purpose, 20 c.c. should be injected two days before, and 10 c.c. on the morning of the operation. If there be not time for this, the injection of 20 c.c. the night before, and a similar quantity on the morning of the operation, must suffice. A syringe must be used which can be disinfected by boiling, and the best place for the injection is in the flanks or the loins; the skin should be thoroughly purified. The question of the value of this remedy is still *sub judice*, and, as there are probably several forms of pathogenic streptococci, it is well not to place too much reliance on it in any given case.

Vaccines have been employed with advantage, especially when the infection runs a chronic course. The question of vaccines is dealt with in detail by Dr. Emery (see p. 514).

TREATMENT OF INCISED WOUNDS INFLICTED ACCIDENTALLY.

A wound may not come under the notice of the surgeon until it has been inflicted some hours, and the problem then is not so much how to prevent the entrance of bacteria into the wound, as how to destroy any that may have already entered. The degree of the contamination of such a wound depends largely on the part of the body injured, and on the weapon with which the wound has been inflicted.

In wounds of the scalp there is certain to be considerable infection from hairs or scurf carried into the wound at the time it is made; and as suppuration in scalp-wounds is often very serious, both from burrowing of pus under the scalp, and also from the proximity of the diploë and the meninges, it is very important that these wounds should be disinfected thoroughly. When earth or grease has been extensively ground into the wound also, great pains must be taken in the disinfection, especially in compound fractures or wounds of joints. The treatment of these two important groups of accidental wounds is dealt with in connection with the affections of bones and joints. Wounds of the face, or of parts not covered by clothes or hair, are not so likely to be seriously infected if the wounds be incised; if they be contused or lacerated, however, the blunt instrument which inflicted them may have carried in a quantity of dirt, and, in addition, the edges of the wound are usually bruised and of imperfect vitality.

Treatment.—When the contamination is trifling, it may suffice to wash out the wound well with a 1 in 20 carbolic acid solution, but in wounds in which earth or dirt is obviously present the treatment must be much more thorough. No attempt should be made to obtain healing by first intention over the whole of the wound, and therefore the increased temporary irritation of the tissues by the strong antiseptics used for thorough disinfection is a matter of no consequence. In badly soiled cases, and especially in compound fractures, it is best to give the patient an anæsthetic, and then to scrub the wound thoroughly and methodically with a nail-brush and strong mixture (see p. 50), picking out dirt or foreign bodies with forceps, and clipping off portions of the tissues into which dirt is obviously ground. When this has been carried out, undiluted carbolic acid should be applied to the entire surface of the wound by means of a swab. In applying it, the margins of the wound in the skin should be avoided, as it may be necessary to stitch them together after the purification has been effected; all the deeper parts should be brought well into contact with the acid. When the wound in the deeper parts is larger than the opening in the skin, the latter must be freely incised, so that the whole extent of the wound is exposed.

Treatment of a Scalp Wound.—When, however, there is no dirt, grease, or other foreign material ground into the wound, and the soiling of the tissues is very slight, the wound can be disinfected satisfactorily with strong mixture. A good example of a wound of this kind is a scalp-wound not involving the skull or pericranium, where hairs and scurf are present in the wound. We shall therefore take it as a type, and describe the treatment in detail.

The scalp should be shaved for about an inch in all directions around the margins of the wound, and the shaved surface and the hair around disinfected with strong mixture as in disinfection of the skin elsewhere (see p. 100). After this, the entire surface of the wound is cleansed thoroughly and methodically with strong mixture, and any tags of injured tissue are removed. If the wound be an incised one, its edges may be approximated accurately by means of silkworm-gut sutures. Drainage should be employed in all cases lest the above measures should fail to secure asepsis ; a fairly large drainage-tube should be inserted at one angle, and should extend into any recess that may be present beneath the scalp. After the wound has been disinfected and drained, the hair in the vicinity should be impregnated with a paste made by mixing the double cyanide of mercury and zinc with 1 in 20 carbolic lotion; this is rubbed into the hair, which is thus converted into an antiseptic dressing.

If the wound be a lacerated one, and particularly if it be inflicted by a dirty blunt instrument, it will be well to swab it over with undiluted carbolic acid before bringing its edges together, and it is not necessary to devote any great care to their approximation, because primary union will probably only be partial at best ; just enough stitches should be employed to keep the flap in place. Antiseptic dressings are then applied (see p. 150).

Unless there be pain or some other sign of sepsis, the wound should be dressed in about four days, and then the drainage-tube may be left out and the wound allowed to close. If, however, the attempt to secure asepsis has failed (as will be evidenced by local inflammation and general fever), the dressings must be changed more frequently ; but in no case is it advisable to wash out the wound with an antiseptic solution.

TREATMENT OF WOUNDS ALREADY SEPTIC.

Another group of incised wounds, not made by the surgeon, that demand consideration are those in which several days at least have elapsed between their infliction and the time they come under the surgeon's notice. Wounds of this kind may be divided into open granulating wounds, and those in which there is only a small opening at the surface and a deep track running inwards ; this latter condition is known as sinus or fistula.

Treatment. — **Of Open Granulating Wounds.** — Unless these are extensive, involve important structures, or are situated on parts exposed to frequent movement, they generally heal readily, provided that there be free exit for the discharge, which is the first essential in treatment. If the inflammation be only slight, an antiseptic gauze dressing (see p. 150) may be used and changed daily ; when, however, the discharge is foul, a lotion of peroxide of hydrogen (10 vols.) in addition is useful. When there is much inflammation in the neighbouring parts, and especially when the wound is lacerated or contused, constant irrigation (see p. 32) may be employed. When the wounds are in important situations, such as the palm of the hand, or close to and involving tendon sheaths, bones, and the like, it is advisable in addition to make an attempt to obtain thorough and immediate disinfection of the part. This can be done most effectually by putting the patient under a general anæsthetic, scraping all the granulation-tissue from the surface of the wound with a flushing spoon (see Fig. 52), and sponging it over with undiluted carbolic acid, which is afterwards washed away with a 1 in 2000 solution of perchloride of mercury. Iodoform may then be sprinkled over the wound and gauze dressings applied. When the wound is superficial and freely exposed, this will generally secure its disinfection. If there be any objection to the administration of an anæsthetic, and if the wound be small, a similar result may be obtained by packing it with lint or gauze soaked in strong carbolic oil (1 in 5) and applied to the wound without being wrung out; this is changed night and morning, and the surrounding skin is washed with a 1 in 20 carbolic acid solution. The strong carbolic oil is not an actual caustic, but it prevents healing; it should be discontinued as soon as the wound has assumed a healthy appearance, and strong boric ointment substituted until healing commences at the edge, when the half-strength ointment should take its place.

When Septic Sinuses are present.—When septic sinuses are present within the area of operation—as, for example, in sequestrotomy—they should be thoroughly scraped with a sharp spoon and swabbed with undiluted carbolic acid before the operation is begun, so as to minimise the risk of infecting the wound that the surgeon makes during the course of his operation. After the operation has been completed, the septic cavity should be scraped again, and undiluted carbolic acid applied, after which the walls of the sinuses should be cut away as completely as possible. In this way, an aseptic wound will be obtained in a considerable number of cases. When the latter is small or superficial, one or more large drainage-tubes should be inserted into the most dependent parts of the wound, the skin-edges brought together with silkworm-gut, antiseptic dressings applied, and the wound treated as if it were one made through unbroken skin. Should the attempt to purify the wound fail, the best dressing is boric lint.

When, however, the cavity in the deeper parts is large—as after operations for necrosis of the tibia or femur—it is best to pack the wound with cyanide gauze, without attempting to bring its edges together. Unless this be done, the opening in the skin is likely to close so rapidly that the discharge from the deeper parts cannot escape freely, and healing does not occur; moreover, the irritation of the gauze leads to more rapid growth of granulations, which thus fill up the wound. The external gauze dressing should be changed on the day following the operation, and subsequently as often as the amount of discharge present may demand. The packing, however, should not be removed until it becomes loose; it should be gently pulled upon at each dressing and any loose portions cut away. After the loose portion has been cut off, fresh gauze should be laid on the remaining packing so as to fill up the cavity. When the wound remains aseptic it may be two or three weeks before all of it can be removed. Should the wound become septic, the packing comes away readily, and should then be renewed daily until the cavity has become almost obliterated. When the granulations are near the surface, the packing should be given up, and weak boric ointment substituted. The opening in the skin has a constant tendency to close and leave a narrow sinus leading into a comparatively large cavity. When the cavity is of such a size or in such a situation that it is evident that a long time must elapse before it can fill up, it is a good plan to remove freely the skin around the margin of the opening at the time of the operation; any overhanging portion must always be cut away, as it would only become inverted and delay healing. Inversion of the edges of the skin sometimes occurs during healing, and the inverted portion may have to be excised.

CHAPTER VIII.

PUNCTURED, CONTUSED, LACERATED, AND POISONED WOUNDS; BURNS, SCALDS, AND FROSTBITES.

PUNCTURED WOUNDS.

Characters.—A punctured wound is one made by a narrow instrument so that its superficial area is small in proportion to its depth; there is generally a comparatively small opening in the skin leading into a large irregular wound in the deeper parts. The peculiar features of the punctured wound are due to the elasticity and contractility of the injured parts; the elasticity of the skin tends to diminish the opening in it and, on the other hand, the contractility of the muscles beneath tends to increase the size of the wound in them.

Results.—The results of punctured wounds depend largely on the particular structures injured. When no important structure has been wounded, the pain is usually slight and the hæmorrhage trifling. If, however, an artery be punctured, profuse bleeding results; this is the usual way in which a false aneurysm is produced. In punctured wounds of the abdominal wall, the instrument may penetrate the abdominal cavity and injure one of the viscera, and special symptoms will then occur, the characters and treatment of which are considered under affections of the particular organ in question. Further, if the instrument which caused the puncture pass through clothing, or if the puncture be in a hairy part, infective material is likely to be carried into the soft parts, and a septic wound may be produced.

Treatment.—In all punctured wounds it is advisable to enlarge the aperture in the skin sufficiently to give thorough access to the deeper parts, which should be cleaned out, the blood-clots removed, and the hæmorrhage arrested. The wound should then be washed out with a 1 in 20 carbolic acid solution, any divided muscle stitched together, and any other important injury to the deeper parts (*e.g.* division of nerves) repaired. When this has been done, the incision which the surgeon has made in order to gain proper access to the wound should be stitched up, and a small drainage-tube inserted at the seat of puncture. The puncture would seldom heal by first intention if the edges were brought together throughout, and therefore it is well to leave an opening in case sepsis should occur, as it is impossible to be certain that all septic material has been destroyed.

CONTUSIONS AND CONTUSED WOUNDS.

A **Contusion** is a severe bruising of the tissues unaccompanied by rupture of the skin. The parts subjected to the bruising are more or less torn, and hæmorrhage occurs into them, so that if a contused area be opened up, it is found to be partly torn and partly infiltrated with blood-clot.

When the skin is torn at the same time, a **contused wound** is produced, and this is characterised by irregularity of the rent in the skin and raggedness of the edges, which are much bruised and infiltrated with blood; the deeper parts of the wound and the parts around are also bruised and bloody.

Causes.—Contused wounds are caused by crushes, run-over accidents, bites, gunshot injuries, and the like. As a rule there is not much bleeding, the vessels being torn and blocked; there is often great pain, and the healing of the wound is always slow. Should septic infection occur, there will be suppuration and sloughing of portions of the contused tissues; if the wound remain aseptic, healing of the deeper parts takes place by blood-clot, and this is naturally a prolonged process.

Treatment.—In the case of a simple **contusion,** the first object is to prevent any increase in the hæmorrhage that has already taken place. If the contusion be large, an icebag, or, if small, an evaporating lotion (see p. 9) should be applied for the first eight or ten hours; the limb or the affected part should be kept at rest, upon a splint if necessary, in the elevated position. As soon as it is evident that no fresh effusion is going on, the indication is to promote the absorption of that already poured out, and for this purpose a firm starch and cotton-wool bandage is very efficacious (see p. 23). When the bulk of the effused blood has been absorbed, the disappearance of the remainder is greatly facilitated by careful massage (see p. 23). When the damage to the muscle is severe, appropriate treatment must be adopted for this (see Injuries of Muscles).

The treatment of a **contused wound** is directed primarily towards securing asepsis; the tissues are so much damaged by the injury, and so much blood is extravasated into them, that they are liable to become the seat of severe septic inflammation, even though the organisms that have gained access to the wound be not very virulent. As a first step, free access must be provided to the deeper parts, and for this purpose the skin wound must be enlarged, if necessary, so that the whole wound can be purified. The particular method employed for purification will depend to a considerable extent on the cause producing the wound. When the skin is burst rather than actually torn or cut by an instrument, and the case is seen immediately after the receipt of the wound, the chances are that septic organisms have not penetrated deeply. On the other hand, when the patient has fallen on stones or has been run over by a cart, dirt containing septic organisms has probably been ground into the tissues. In the milder cases, it is sufficient to wash out the wound with 1 in 20 carbolic lotion, or, perhaps better, with strong mixture (see p. 50), and to scrub the skin with a nail-brush and strong mixture. When dirt is evidently ground into the tissues, and especially when bone is injured, it is best to clip away any dirty tissues and tags of skin and muscle, and then to wash out the wound with strong mixture, and finally to sponge it over with undiluted carbolic acid. The patient should be under a general anæsthetic while the wound is being cleansed in these bad cases. No stitches should be employed; the wound should be left freely open and a cyanide gauze and salicylic wool dressing should be applied; should the wound prove aseptic, a piece of sterilised protective, sheet rubber or tinfoil should be applied to its surface after a day or two, in order to prevent the irritation that this dressing would otherwise cause. Skin-grafting may be usefully employed (see p. 54) if a considerable raw granulating surface be left.

Should suppuration occur in these contused wounds, with much local inflammation and a tendency to sloughing, irrigation (see p. 32) is the best treatment; it should be discontinued, however, when the wound becomes covered with granulations, and either the gauze dressing or, still better, one of the various antiseptic ointments employed; the full-strength boric ointment should be used until it is evident that healing has begun at the edge, and then half-strength ointment substituted for it, so as not to interfere with the growth of the young epithelium.

LACERATED WOUNDS.

In lacerated wounds proper—namely, those caused by tearing— he bruising of the deeper tissues is not nearly so marked as in wounds inflicted by a direct blow with a blunt instrument. The wound is usually comparatively superficial except when a limb is torn off. The soft parts are much torn, and there are shreds of muscle and fascia which are more or less completely deprived of blood-supply and will slough should the wound become septic; in fact, they will probably do so in any case. The wound is usually much soiled with dirt or grease, especially in machinery accidents. These wounds are inflicted by a blunt instrument, which tears the tissues rather than contuses them; the most typical example of this is in machinery accidents, where a toothed instrument catches the skin and tears it off for a considerable distance. Lacerated wounds are always to some extent contused wounds, and a contused wound may also be a lacerated one.

Treatment.—The patient should be put under a general anæsthetic, all tags clipped away, and the skin and the soft parts thoroughly scrubbed with a nail-brush and strong mixture, or even sponged with undiluted carbolic acid should there be marked soiling of the wound. It is useless to stitch the torn skin together; at most one or two stitches should be inserted in order to keep the flaps somewhat in position. Tension must be avoided; it would certainly lead to sloughing of the flaps, as their vitality is already much interfered with. Gauze dressings should be used at first; should suppuration and much local disturbance occur, recourse must be had to irrigation with weak Condy's fluid, hydrogen peroxide, or sanitas solutions. Many of these wounds, however, will heal by blood-clot if they be small and be rendered aseptic by the purification described above; at any rate, the greater part will heal in this manner, though possibly after a time granulation may occur towards the centre of the wound from the irritation of the dressing. When the wound is aseptic, there will be comparatively little separation of sloughs either from the skin or from the deeper parts, the aseptic slough, like a blood-clot, acting as a mould in which new material is formed.

When much skin is torn off an extremity, the *question of amputation* arises. When, for instance, the whole skin of the forearm has been lost, the wound often does not heal at all on account of its large size or, if it does, so much contraction results that the movements of the joints are permanently interfered with, the result in bad cases being so unsatisfactory that amputation is often considered the best practice. It is well, however, to bear in mind that many of these cases can be got to heal by skin-grafting, and a very useful limb may result, so that the former rule of amputating in all cases of extensive loss of skin does not apply universally at the present time. In many cases extensive wounds can be induced to heal without any marked contraction by allowing the wound to granulate, and then applying Thiersch's skin-grafts (see p. 54) before contraction has taken place, after scraping away the soft granulation tissue which has already formed. Amputation can always be performed later on should it be found that, after all, the functional result is not satisfactory.

Even after skin-grafting has been employed, efforts must be made to counteract the great tendency to contraction during healing by the careful application of splints. For example, in the case of loss of skin and fascia at the bend of the elbow, the arm must be kept extended upon an anterior splint; when the loss is about the back of the hand the fingers should be flexed during the healing process, the principle being that, if contraction be likely to occur in a certain direction, it is best counteracted by fixing the limb on a splint bent in the opposite direction. It must also be borne in mind that the tendency of the scar to contract does not cease when healing is complete ; a young scar will go on contracting for three or four months at least. Hence, when the skin over a joint is involved, the use of a splint must be continued for at least that length of time after the wound has healed. It may not be advisable for the patient to wear the splint night and day for the whole time, as a certain amount of movement of the joint must be allowed in order to keep up its mobility and the nutrition of the muscles about it, but the splint should be constantly used for two or three months, and then it may be worn during the night only for another period of about three months. Massage and passive movements to ensure proper mobility in the neighbouring joints, and to restore tone to the muscles, are valuable auxiliaries in stretching the scar.

POISONED WOUNDS.

VARIETIES.—In speaking of poisoned wounds, reference is usually made only to those following *post-mortem* examinations, dissections, or operations, especially upon parts containing foul pus. We shall restrict the term here to these conditions. The most common variety is the *post-mortem* wound, and there are three distinct varieties of infection which may arise in this connection.

Lupus Anatomicus.—This is the mildest form and is also known as the anatomical wart. It consists of warty growths which appear on the fingers of pathologists and *post-mortem* porters, and which are really tuberculous in nature. The soft warts are often rebellious to treatment, and in a certain number of cases they give rise to disease elsewhere—for example, tuberculous glands in the axilla or above the elbow, infection of neighbouring joints or sheaths of tendons (tuberculous synovitis, or teno-synovitis), lung disease, etc. Hence it is important to recognise and remove the warts as soon as possible.

Treatment.—The best treatment is to excise the growth, going wide of it in all directions ; the result is quite satisfactory provided that the wart be small, as a skin-graft can be applied to the raw surface, and subsequent contraction avoided. Even when the warty growth is extensive, it can best be got rid of in this way ; should the tendons be exposed in the dissection, loss of movement need not be feared if the whole raw surface be covered with skin-grafts.

Should the size or situation of the diseased area prevent excision, the warty material may be scraped away with a sharp spoon under a general anæsthetic. After the bleeding has been arrested, the surface should be vigorously rubbed over with nitric acid, which should be allowed to act for ten minutes, when a solution containing half an ounce of carbonate of soda to a tumblerful of water is poured over the sore to neutralise the acid ; vigorous effervescence occurs from the formation of carbonic acid, but this ceases as soon as the nitric acid is neutralised. By far the best method of treating this disease, however, is by excision and subsequent skin-grafting. If an anæsthetic be refused or be contra-indicated, acid nitrate of mercury should be applied instead of the nitric acid.

Local Septic Infection.—The other troubles which arise from *post-mortem* wounds are septic infections, either local or general. The results of local septic infection vary in severity from the formation of a small pustule or abscess, to an extensive diffuse cellulitis spreading from the fingers up the hand and arm ; the treatment of these conditions has been already described (see Chap. II.).

General Septic Infection.—The most serious result of a *post-mortem* wound, however, is acute septicæmia. This is perhaps most likely to occur when a wound is inflicted accidentally while making *post-mortem* examinations on patients who have died of suppurative peritonitis ; here the organisms in the pus are particularly virulent. The patient soon passes into the typhoid state, and may die in from thirty-six to forty-eight hours.

Treatment.—In this acute form of septic poisoning there is little hope of a successful result, as the disease is too rapid for any satisfactory intervention. The infection is usually due to streptococci, and therefore a trial should always be made of anti-streptococcic serum. About 20 c.c. should be injected when the patient is first seen, and this should be followed by a further 20 c.c. in the course of the next twelve hours. Doses of at least 10 c.c. should be given every night and morning, and they should be continued for at least two days after the temperature has fallen to normal. In some cases good results are obtained by larger doses—*e.g.* 40 c.c. In all, the so-called ‘ polyvalent ’ serum—*i.e.* that prepared from a number of different strains of streptococcus—should be employed.

Stimulants, such as brandy in doses of an ounce every two to four hours according to the gravity of the case, must be given, and as much fluid nutritious food (beef essences, egg-and-milk, etc.) as possible should be administered. Quinine should be given in doses of ten grains every four hours for twenty-four or forty-eight hours in spite of any symptoms of cinchonism that may arise. The wound should be swabbed out with undiluted carbolic acid, but the local symptoms are usually slight and seldom call for special treatment. This acute form is extremely fatal, and the chance of the patient's recovery is small. The subject will be considered again in connection with infective diseases of wounds (see Chap. IX.).

BURNS AND SCALDS.

CAUSES.—Burns and scalds are caused by contact with solids, liquids, or gases at a high temperature or by exposure to strongly actinic light, X-rays, electrical discharges, or radiant heat. Radiant heat only causes superficial burns, such as blisters and erythematous conditions of the skin. Liquids below 212° F. cause erythema, but at or above that point they produce extensive burns, especially if the liquid has fallen upon the clothes, because then it remains in contact with the skin for some considerable time before the patient can divest himself of his clothing. Caustic liquids cause extensive sloughs. Red-hot or white-hot solids cause deep and limited lesions ; fused metals are extremely rapid in their action and char the parts completely.

X-rays, when applied for a prolonged period, produce symptoms resembling an acute burn, which, however, do not develop for a week or a fortnight after the exposure. The skin then rapidly becomes red, œdematous, blistered, and extremely painful. Under appropriate treatment this subsides and leaves no ill results beyond a temporary or permanent epilation. Repeated small exposures to X-rays produce an entirely different train of phenomena. The skin becomes glossy and atrophic, the nails dry, brittle, and cracked, while teleangiectases and warty growths appear over the affected area ; in severe cases there may be extensive sloughing and necrosis necessitating amputation, and in some cases epithelioma of the skin has been produced. When the patient has been exposed to the passage of a high voltage current, especially if its action has been prolonged, electric burns are produced which are generally complicated by ordinary burns produced by ignition of the clothes. The affected skin is red and œdematous, resembling the condition met with in X-ray burns, but the symptoms come on immediately. In electric wire-men curious appearances may be produced by the volatilisation of fuses, especially when these are of copper, the patient's hand being coated with a thin layer of the metal as if it were part of a bronze statue. With low-voltage currents serious burns may result ; for example, if a naked wire be allowed to lie in contact with the skin for a few minutes in the operation of electrolysis a white, apparently dead, area is produced at the point of contact ; part of this recovers, but much of it will necrose. *Radium* gives rise to a burn of varying depth, which is painful and slow to heal.

SYMPTOMS.—The **local phenomena** of burns are usually described under six headings or degrees as originally proposed by Dupuytren. The *first degree* is caused by the transient action of a flame, or by a body below 212° F., and is marked by redness of the skin, followed by some swelling and pain, and subsequently by desquamation. The *second degree* is caused by a more prolonged action of a flame, by boiling water, or by solids at 212° F.; and in this case the Malpighian layer of the skin is disorganised, and inflammation, as shown by erythema and the formation of bullæ, follows. The *third degree* is reached when one of the foregoing causes has acted for a longer period, or when the burn is caused by red-hot metal, boiling salt water, or oil. Here there is destruction of the epidermis, the Malpighian layer, and the papillæ of the skin, the result being that there is erythema, the formation of bullæ and superficial dry eschars; the slough separates in about a week. In the *fourth degree* the whole thickness of the skin and part of the subcutaneous tissue are destroyed; there is a black eschar with a white circle around it, and a zone of redness beyond that. There is less pain in this form of burn, but the healing is slow. In the *fifth degree*, not only the skin, but the subcutaneous tissue and portions of the muscles are completely destroyed; it is caused by the long-continued action of flame or red-hot metals, or chemical substances such as arsenious paste, caustic potash, etc.; a dry slough is formed, around which are seen the various minor degrees of burns, from sloughing of part of the skin near the eschar to simple erythema at a distance. In this form of burn joints are frequently opened, especially as the slough separates, and consequently very serious results may ensue. The *sixth degree* of burn is that in which all the tissues of the limb are charred, and there is complete destruction of the part subjected to the heat.

A later phenomenon in burns is the occurrence of a certain amount of inflammation around the burnt area, due directly to the action of the heat; besides this, there may be septic infection with severe local and general results if the parts have not been rendered aseptic. Later still there is the separation of the slough, granulation, and healing.

The **constitutional phenomena** are divided into three stages, which need only be alluded to. The *first stage* lasts for forty-eight hours, and is marked by congestion of the parts in the neighbourhood of the burn, and great pain; besides this, there may be congestions of internal organs. Thus, for example, when the burn is situated over the thorax, the pleura or the lungs may become congested; when it is over the skull, the meninges may be similarly affected, and so on. During this stage also there are other serious dangers—for instance, shock, delirium, convulsions, asphyxia from carbonic acid or carbonic oxide, or death with symptoms of poisoning attributed to absorption of the partly broken-up products of the burnt tissues. The *second stage* of burns lasts from the second to the sixth or eighth day, and is termed the inflammatory period; this is marked by inflammation of the part, with sloughing of the dead tissues, and a tendency also to inflammation of internal organs; for example, a burn over the head may be accompanied by inflammation of the brain, a burn over the thorax by inflammation of the pleura or the lungs. It is during this stage also that a peculiar phenomenon frequently noticed in burns—namely, inflammation and, in some cases, ulceration of the duodenum—is observed. This occurs at the point where the contents of the bile duct impinge on the intestinal mucous membrane, and is possibly due, as was suggested by Dr. William Hunter, to the excretion, with the bile, of irritating products resulting from an imperfect carbonisation of the tissues. In other cases hæmaturia or hæmoglobinuria occurs. The *third stage* begins when the slough separates, and is mainly occupied by the healing process. Towards the end of the second, and in the early part of the third stage, the patient is liable to various general septic diseases and also to local septic troubles due to the position of the burn; for example, when this is situated over a cavity such as a joint or the pleura, either may be opened as the slough separates, and violent septic arthritis or pleurisy may follow.

The Causes of Death after Burns depend mainly on the extent, but partly also on the depth, of the burn and the region of the body affected. An extensive superficial burn is more dangerous than a limited but deep one, whilst a burn over the head or the thorax is far more serious than a more extensive one on an extremity. The causes of death after burns are (1) shock, (2) collapse, (3) poisoning from absorption of partially broken-down organic products at the seat of the injury, (4) congestion of various internal organs, (5) inflammation of these organs, (6) intestinal ulceration, (7) various septic diseases, particularly erysipelas, septicæmia and pyæmia, and (8) exhaustion. In burns in particular situations of course there are special dangers; for example, in scalds of the throat there is the danger of œdema glottidis and death by suffocation. When the patient has been burnt in an explosion in a mine or in a burning house there may be symptoms due to asphyxia or carbonic-oxide poisoning.

TREATMENT.—The treatment may be described under four heads—namely, the treatment of the first degree, that of the second, that of the third and fourth degrees, and, lastly, that of the last two degrees. It is also important to consider both local and general treatment.

General Treatment.—The general treatment will depend largely upon the extent and result of the burn. When a patient comes under observation suffering from severe *shock*, the various measures appropriate for the treatment of that condition (see p. 120) must be employed.

During the early stage also, apart from shock, it may be necessary to counteract *carbonic-oxide poisoning*, which is indicated mainly by the presence of dyspnœa, while the mucous membranes are of a cherry-red colour and the pulse is slow. A drop of blood from a needle-puncture shows marked deviation in colour from normal blood: it is of the same bright cherry-red as the mucous membranes. This condition is due to the carbonic oxide entering into combination with the hæmoglobin, and preventing the corpuscles from fulfilling their functions as carriers of oxygen.

Carbonic-oxide poisoning must be treated by free stimulation, combined with efforts to promote the oxygenation of the blood. Most benefit will be obtained from the inhalation of oxygen; and until this can be obtained, artificial respiration by Sylvester's method must be carried out if the breathing shows any tendency to flag. If a cylinder of oxygen can be obtained, one end of an indiarubber tube should be attached to it and the other to the mouthpiece of an ordinary Clover's inhaler, a glass funnel, or a piece of brown paper folded into a cone; the oxygen is then turned on and made to pour over the patient's nose and mouth. The mouthpiece should be removed every ten minutes or a quarter of an hour for a minute or two, but the inhalation must be kept up for twelve to twenty-four hours, until, in fact, a sufficient number of new blood-corpuscles have been formed to act as carriers of oxygen. Transfusion of blood has been suggested, but it seems that the blood-corpuscles thus introduced do not retain their vitality for any length of time, and act only very temporarily, if at all, as carriers of oxygen to the tissues. As a stimulant, caffeine given subcutaneously in doses of one grain or more, with an equal quantity of salicylate of soda, and repeated in three or four hours, is of use; brandy will also be called for.

If symptoms of internal congestion or *inflammation* set in after the patient recovers from the shock, the treatment must be conducted partly on the lines indicated for acute inflammation and partly on those appropriate to the organ affected. During the stages of *sloughing* and *convalescence*, it is necessary to support the patient's strength by the administration of a nutritious diet and the use of stimulants and tonics. Blaud's pill (ten grains three times a day) or tinct. ferri perchlor. (ten to fifteen minims three times a day) may be given; quinine (three grains thrice daily) is also of value.

Local Treatment.—The local treatment may be considered in connection with the various degrees of burn. In the **First Degree** the erythema which occurs from radiant heat requires little treatment. The chief trouble complained of is the sensation of heat and burning in the part, and the use of some soothing application, such as cold cream or glycerine, which also acts by protecting the surface from contact with the air, will often relieve it; if not, lead or lead and opium lotion (see p. 9) will be efficacious.

In the **Second Degree**, blisters should be punctured at the most dependent spot, and their contents let out. The epidermis should not be clipped away, and the incision should be just large enough to allow the fluid to escape; if the blister be opened freely the epidermis is apt to peel off, exposing the papillary layer of the skin, causing a good deal of pain, and retarding the healing. When the injury has not gone beyond the formation of blisters, it is unnecessary to use antiseptic lotions, because the denudation of the papillary layer does not entail any serious risk of sepsis; it is best to apply an antiseptic ointment over the blisters after they have been pricked.

Eucalyptus ointment is an excellent application, but half-strength boric ointment also acts well.

In the **Third and Fourth Degrees**, when there is partial or entire destruction of the whole thickness of the skin or of the deeper tissues, great care must be taken to keep the parts aseptic, because the patient's greatest risks are connected with sepsis after recovery from the shock and for the first week or two afterwards. How best to secure asepsis is a question of considerable difficulty, for it must be remembered that burnt parts absorb fluids with extraordinary rapidity, and this is especially the case with regard to carbolic acid. Hence, if this drug be freely used as a disinfectant in burns, grave symptoms of carbolic poisoning, possibly ending in the death of the patient, may result. Therefore the strong mixture should not be used for the wound, and reliance must be placed on 1 in 1000 sublimate solution. The undamaged skin around the burnt area may be safely cleansed with strong mixture.

Since the heat itself has disinfected the part, it is not necessary to employ disinfectants with the thoroughness required in operations, should the burnt area have escaped subsequent soiling, as may be the case when the patient is seen soon after the accident. Absence of infection may be expected when the burnt part has not been covered with clothes; when, however, clothes have been pulled over the part in removing them, great care must be employed in disinfection. As the patient is suffering from shock and as the manipulations necessary for disinfection are very painful, additional shock will be avoided if a general anæsthetic be administered. Therefore it will often be better to apply some simple dressing such as ung. eucalypti in the first instance, and to administer a full dose of morphine, and so to allow the patient to rally from the shock. He is then put under an anæsthetic, the skin around is purified carefully with strong mixture, and then it and the burnt area are washed thoroughly with a 1 in 1000 sublimate solution, which is subsequently removed by douching with sterilised saline solution.

The best dressing is cyanide gauze rinsed out in a 1 in 8000 sublimate solution, and salicylic wool. The dressing should be left undisturbed for two or three days if the temperature remain normal and the patient be comfortable; indeed, should there be no evidence of sepsis after two or three days, the dressings may be left on for a week or even longer, any scabs which form being soaked off at each dressing. The advantage of this dressing is that it keeps the part aseptic and also allows the discharge to dry on the surface; a reference to Chap. IV. will show that one of the most important points in the treatment of gangrene is to promote drying of the part. When the slough begins to separate (sometimes it does not do so, but becomes organised in the same way as blood-clot) and the parts around are granulating well, eucalyptus or boric ointment may be substituted. When the slough has separated, the wound must be treated as a healing ulcer (see p. 51), and, if it be of any size, the sooner it is skin-grafted the better (see p. 54). When the slough is unduly slow in separating boric fomentations will hasten the process.

Picric acid is much used for superficial burns, as it is said to allay the intense pain effectually. It may be employed either as a saturated watery solution, painted upon the burnt area with a camel's-hair brush or applied on butter-muslin, or as an ointment containing one drachm of the acid in an ounce of vaseline. The drug is not without its dangers, as toxic symptoms—*e.g.* a rash, pyrexia, and greenish-red urine—have followed its use. The acid coagulates the albuminous fluid oozing from the sore, and forms a protective layer over the exposed nerve-endings in the skin. The application should be made once or twice daily, according to the size of the burn and the amount of discharge from it. We have found it useful in superficial burns; for the more severe ones we prefer the method just described.

It is necessary to warn the practitioner against certain commonly recommended applications for burns. Carron oil (a mixture of linseed oil and lime water), for example, is a filthy application; poultices or water dressings and dusting with flour are equally bad. The wound must be treated aseptically as far as possible, as sepsis is the primary cause of death in a large number of deep burns.

Should the case come under observation with a foul sloughing wound, or should the attempt at disinfection fail, and the wound become septic, the best method of treatment probably is the water bath. If the trunk be affected and the burn be large, very painful, or accompanied by constitutional disturbance, the patient is placed in a bath, the water (at a temperature of 100° F.) containing a small quantity of an antiseptic, such as Condy's fluid or sanitas, and being changed every three or four hours. The patient should be taken out of the bath at night, and a wet boric lint dressing applied; this consists of boric lint boiled in a saturated solution of boric acid and applied warm and wet; outside this is placed a larger piece of sterilised jaconet or gutta-percha tissue. Next morning the patient is again placed in the water bath, and kept in till evening, and this is continued until the sloughs have separated and the inflammation has subsided. Then boric dressings, antiseptic ointments or protective and boric lint, applied as for healing ulcers (see p. 51), should be substituted. When the extremities are affected, special baths (see p. 34) will be required.

If the burn be of any size, skin-grafting should be employed (see p. 54) as soon as the sloughs have separated and the wound has begun to granulate; this is especially necessary in burns, because the sores resulting from them have a peculiar tendency to contract. Sores left by burns heal much more slowly than wounds made by the knife, probably because the heat not only destroys the vitality of the part immediately acted upon, but also impairs that of the tissues around, so that in the early stages the vital processes in them are not so active as usual.

Therefore there is more granulation tissue formed, and greater subsequent contraction.

When the slough is situated over a joint or a serous cavity, and there is reason to fear that either may be opened when the slough separates, special care must be taken in the antiseptic management of the case, because, should the part become septic, there may be acute suppuration of the articular or the serous cavity.

In the **Fifth and Sixth Degrees** the treatment is only of importance when the burn affects the extremities; if it be situated elsewhere, the patient usually dies at once. Should a burn of these degrees occur upon the skull or part of the trunk, however, and should the patient survive, the aim of the surgeon must be to render and keep the part aseptic, to support the patient's strength, and to wait until the slough separates; then, if no vital part be involved, the defect will be gradually filled up with granulations, and a time will come when skin-grafting can be employed. In the extremities, however, the question of primary amputation arises, when the tissues down to and including the bone are completely charred, or when only the fifth degree is reached, and the tissues are destroyed over a large area. This question must be answered in the affirmative when the extremity is hopelessly destroyed; the only points for discussion are as to when and where the amputation should be performed. As a rule it is best to wait until the shock has passed off, for if amputation be performed before this, as is frequently the case, the shock is apt to be much increased, and to bring about a fatal result. In the majority of cases it is quite safe to wait for from twelve to twenty-four hours, if the part be roughly disinfected and wrapped up in an antiseptic dressing; when the shock has been recovered from, at any rate partly, amputation may be proceeded with, taking care to employ all the measures calculated to prevent or minimise shock (see p. 118). Spinal analgesia here finds one of its most useful applications. In determining the level at which to amputate it must be remembered that it is not necessary to go far above the actually charred tissue; there is certainly no need to go above the region of the erythema. If the part be kept aseptic this congestion will subside without leading to any trouble during the healing of the stump; special attention must be devoted to the purification of the skin in the region of the amputation.

EFFECTS OF INTENSE COLD.

The local effects of intense cold in some respects resemble those of heat. The parts chiefly affected are those most distant from the heart, such as the toes and the fingers (especially the great toe and the little finger), the nose and the ears. Moist cold is more likely to do harm than dry, and when there is wind, frostbite is much more likely to occur than when the atmosphere is still. The effect of cold is to cause great local contraction of the vessels, so that the part at first becomes livid and ultimately white. On the cessation of the cold, reaction takes place; the vessels become greatly dilated, and stasis is apt to occur and may end in thrombosis if the reaction be too severe. When death results from cold, the most common appearance met with *post-mortem* is thrombosis of the vessels of the internal organs. Various other local changes are described as the result of cold, the most important being degeneration or inflammation of nerves; these may possibly have something to do with the peculiarly languid ulcerations which affect parts that have been exposed to severe cold. The changes probably result from thrombosis of the nutrient vessels of the nerves.

The clinical effects of cold may be divided into three degrees. The *first degree* corresponds to the first degree of burns: it consists simply of erythema of the part, and is a reactionary phenomenon: the *second degree* corresponds to the second degree of burns, at any rate to a great extent; and the *third degree*, or frost-bite proper, may be taken to represent the remaining degrees of burns.

Chilblains.—The first effect of cold is erythema. The skin becomes of a wine-red or violet colour, which disappears on pressure; the cutaneous circulation is slow and there is swelling of the skin and subcutaneous tissues, with a feeling of numbness in the part. In addition to this feeling of numbness there is much itching and pricking, if heat be applied too suddenly. This condition generally disappears in a few days; if, however, the exposure to cold, followed by the application of heat, be repeated, it may lead to the condition known as chilblain which, if not properly treated, may become cracked and ulcerated.

Ulcers.—The second degree of cold leads to the formation of bullæ containing clear or bloody fluid, and these may be followed rapidly by atonic ulcers which show little tendency to heal; there is also smarting in the part. When the condition is yet more chronic we have what are practically ulcerating chilblains, the skin being swollen, œdematous, cracked, and marked by shallow fissures which yield a yellow or brownish liquid, very prone to dry up. These cracks enlarge and form obstinate ulcers.

Frostbite.—The third degree is that in which the skin and a variable amount of the deeper tissues die; the skin becomes livid and mottled, and numerous large bullæ, containing rusty-coloured serum, are formed, or else sloughing takes place. If warmth be applied too quickly, the condition results in severe inflammation, followed by gangrene. The gangrene spreads slowly, and there is an imperfect and temporary line of demarcation much the same as in the senile form; if opportunity be afforded, the dead part dries up, but the gangrene is not typically a dry one from the first. In other cases the sloughing is quite superficial, but the frostbite is followed by permanent malnutrition, with anæsthesia, analgesia, or even atrophy of the limb, or by the formation of perforating ulcers.

TREATMENT.—**Prophylactic.**—The treatment of the effects of cold is partly prophylactic and partly curative. As a measure of prophylaxis, persons who must necessarily be exposed to severe cold should take large quantities of fatty food. The clothing should be thick and woollen, it should not be tight-fitting, and the feet especially should be kept warm ; the body, particularly the exposed parts, should be oiled in order to prevent evaporation, and when the patient is exposed to intense cold, he should keep actively moving, and must not yield to the desire to rest or sleep, which is often very great.

Curative.—Of the First Stage.—When the cold has, so to speak, got hold of the patient, he should not be brought at once into a warm room, as otherwise the reaction is likely to be so great that thrombosis of the vessels occurs. The affected part should at first be rubbed with snow or cold water, while, after a little time, dry friction may be substituted, and then the heat very gradually increased. Dry friction should first of all be practised by the hand, for which slightly warmed cloths may afterwards be substituted, and then the patient may be exposed to the air of a warm room at a distance from the fire. When this stage has been passed and the erythematous condition has supervened, the best applications are stimulant lotions, such as camphorated alcohol, rubbed into the part. The question of food is also important. At first both food and drink should be cold, and warm nourishment should be permitted only gradually.

Treatment of Chilblains.—When chilblains are present and the skin is still unbroken, various applications, in which flexile collodion is the vehicle, are of use. The following are the most valuable. When there is great itching, the irritation can be much relieved by the application of flexile collodion containing two per cent. of cocaine. In painting this on a chilblain affecting, say, the toe, care must be taken not to surround the base of the toe completely with it, as otherwise the contraction which ensues as it dries will constrict the toe and interfere with the return circulation. The collodion should, therefore, only be painted on the main portion of the chilblain, and no collodion should be applied on one side (in the case of the great toe, the outer side). When the chilblains are very tender, turpentine is useful, and the following prescription is very satisfactory:

℞	Collodion	2 oz.
	Venice turpentine	6 drachms
	Castor oil	3 drachms.

The turpentine does not allow the collodion to dry completely, and the stocking is consequently apt to stick to the skin ; it is well, therefore, to place a piece of boric lint around the toe outside the collodion as soon as it has partly dried, and this can afterwards be removed with warm water. This application should be renewed at least once daily, or oftener if the patient has been walking about. Glycerinum belladonnæ smeared freely over the inflamed part is also of value, and it is more suitable when the chilblain surrounds the toe entirely; a piece of boric lint is covered with the preparation and wrapped round the toe. Five per cent. salicylic ointment is also a valuable application, while other cases seem greatly benefited by a few short exposures to the X-rays.

When the chilblains are *ulcerating*, the best application is a piece of lint soaked in balsam of Peru, and with some excess of it on the surface. In changing the dressings, the chilblain should be bathed with warm boric lotion; the application should be renewed night and morning.

Cod liver oil (ʒj) and syrup of iodide of iron (♏xx-xxv) should be given internally three times a day. Ichthyol in pills of 1 to 3 gr. thrice daily is said to be valuable. Nourishing diet, with plenty of fatty food, should be given, and when the chilblains affect the feet and have ulcerated, the patient must either lie up entirely, or must refrain from walking. In any case thick, warm, undarned stockings, with stout well-fitting boots and warm gloves, should be worn.

Of the Second Stage.—In the second stage of cold, stimulant lotions or balsam of Peru (*vide supra*) are the best applications in the first instance. As the ulceration is usually of an atonic form, everything possible should be done to increase the nutrition of the limb. Massage applied to the whole limb above the limit of the sore will keep the circulation active, and will be of great benefit; electricity in the form of electric baths, or the Faradic current applied to the muscles, and used in precisely the same way as for cases of Raynaud's disease, is of great value (see p. 77).

When the sore begins to heal, half-strength boric ointment may be substituted for the balsam of Peru. The part should be elevated, but it may not be necessary to keep the patient in bed, rest on a sofa often being sufficient; this point, however, must be determined by the progress of the ulcer. If it does not heal, or if it shows signs of spreading when the patient is allowed to remain on the sofa, rigid confinement to bed, with the foot elevated, must be enforced. Cod liver oil should be administered internally, together with stimulants and a nutritious diet.

Of the Third Stage (Frostbite).—In the first place, the part should be thawed by friction with snow (see p. 182), and then wrapped up in cotton-wool. If, however, the frostbite be severe, it is well to disinfect the part at once, shaving the skin, scrubbing it with strong mixture, cleaning the nails, as already described for gangrene (see p. 68), and then wrapping up the limb in cyanide gauze and salicylic wool. Immediate amputation should not be performed; it is advisable to wait for a line of demarcation. It is not uncommon to find that the slough only involves the skin and subcutaneous tissues, or even only the surface of the skin, and a short delay may prove that amputation is not called for. In any case, there is no guide to the proper place for amputation until a line of demarcation has formed, for it is impossible to say at first to what extent the tissues have been irretrievably damaged. As soon, however, as there is a clear indication of the extent of the frostbite, there is no necessity to wait any longer, and amputation may be proceeded with at once. In most cases of frostbite of the foot, a Chopart's or Syme's amputation will suffice; it is seldom that the gangrene reaches the ankle. If, however, the surgeon wait too long, the gangrene is apt to spread (as is the case with the senile form), the weak tissues being unable to resist the inflammation associated with the separation of the dead part. On the other hand, if the amputation be performed antiseptically, no further inflammation occurs, and there is no gangrene of the flaps. Thus, by waiting too long, more tissue may be lost than if the amputation were performed as soon as the appearance of a line of demarcation indicates the extent of the original gangrene.

The general treatment of the third stage of frostbite is similar to that of the less severe forms (see p. 183).

CHAPTER IX.

INFECTIVE DISEASES OF WOUNDS.

In the preceding chapters we have laid the very greatest stress on the aseptic management of the wound, but no consideration of the subject would be complete unless reference were made to the various results which may ensue either when these precautions have not been taken, or when they have been carried out inefficiently.

It must be remembered, in connection with the various septic diseases that may attack wounds, that although such affections as septic intoxication, traumatic fever, septicæmia, and pyæmia are described as different conditions possessing clearly differentiated symptoms and a definite pathology, yet in actual practice there are numerous gradations between them, so that it is often impossible to say where one ends and the other begins. Thus a condition of septic intoxication readily passes into one of traumatic fever, which in its turn may end in one of the forms of septicæmia or of pyæmia. Even septicæmia and pyæmia, which are the two members of the group that differ most widely, may both occur as the result of the septic infection of the same wound. Indeed, seeing that in all probability the same organisms are concerned in most of these affections, it is not illogical to regard the latter as being merely varieties of the one fundamental condition of septic contamination, the particular form that the affection takes depending upon a variety of factors, such as the virulence and concentration of the infective material, the distribution of the organisms, and the anatomical conditions of the part affected.

SEPTIC INTOXICATION.

The organisms which gain access to wounds may be either saprophytes—*i.e.*, those growing in dead tissues or in fluids, but having no power of penetrating into the living body ; or parasites—*i.e.* those which live and flourish in the bodies of animals whose tissues or fluids furnish suitable media for their development ; the latter group are usually capable also of saprophytic growth. Although the true saprophytes are unable to grow in living tissues, they may nevertheless cause serious results and may even bring about the death of the patient whose wounds they infect, for, as they grow in organic materials, they give rise to various poisonous substances, which, if absorbed into the body, may cause the condition known as septic intoxication. Septic intoxication therefore is an affection produced not by parasitic growth in the body, but by the absorption of products of decomposition formed in the wound. These products are mainly the result of the growth of saprophytes, but they are also to some extent produced by organisms which can become parasitic should the patient live.

SYMPTOMS.—The symptoms of septic intoxication are due to the poison which is absorbed into the system. The condition in former days was not recognised as such and was often spoken of as 'secondary shock.' The affection can only occur in large wounds, because it is only in them that sufficient toxic material can be formed to provide a poisonous dose; for example, it may be met with in amputations at the hip joint, operations upon large joints such as the knee, extensive compound fractures, extensive operations about the breast and axilla, many abdominal operations, psoas abscess, and so forth. The clinical history is somewhat as follows. In the first place, the operation being a severe one, the patient suffers from collapse, with depression of temperature, feeble pulse, etc., and as the shock is recovered from, this is followed by reaction with pyrexia. The temperature usually rises considerably within twenty-four hours; then it falls rapidly and the patient again passes into a condition not unlike that of shock. He becomes semi-conscious, the pulse is weak and fluttering, and the temperature low; if this condition persist, he may die. The affection is very grave in those who have renal disease, for whereas the poison is rapidly excreted by the healthy kidneys, the excretion may not be sufficiently rapid to save the patient's life if they are diseased. Hence the old rule, on which so much stress was laid, was that no operation should be undertaken when there was albumin in the urine. Nowadays this does not apply with such rigour, since we do not anticipate such a catastrophe as septic intoxication. Milder conditions of septic intoxication may also occur, in which there is no great lowering of temperature; in them the patient recovers rapidly.

TREATMENT—**Local.**—When the above symptoms appear, the clear indications are to get rid of all decomposing materials from the wound, so as to stop the absorption, and then to support the patient's strength and promote the excretion of the poison which has already entered the body. Hence, the wound should at once be opened up freely, the stitches taken out, and all decomposing blood-clot and other material cleared out. The wound should then be thoroughly *irrigated* with sterilised saline solution at a temperature of about 104° F.; these hot lotions act as a general stimulant and do not damage the tissues. Antiseptics such as carbolic acid should not be used, because they cannot possibly disinfect the wound, and they may be absorbed and render the patient's condition still more serious; further, they cause the formation of a layer of coagulated albumen on the surface of the wound, beneath which the organisms are protected and may grow again.

After the wound has been thoroughly washed out, a few stitches are again inserted and one or more large *drainage-tubes* introduced to provide free escape for the discharge. The cyanide gauze and salicylic wool is probably as good a dressing as can be applied; it should be changed and the wound washed out again through the drainage-tube in the course of a few hours. Whether an anæsthetic should be given for the purpose of opening up and draining the wound depends on the condition of the patient. If he be in a very depressed state it is well to avoid it, as the procedure does not involve any great pain, and the anæsthetic might add to the depression.

General Treatment.—Stimulants are indicated. *Brandy* may be given either by the mouth or by the rectum; in desperate cases it may even be injected subcutaneously and under these circumstances *ether* in ten- to twenty-minim doses may be similarly used; the injection should be made into the muscles, for a slough is apt to form afterwards if it be merely introduced beneath the skin. *Strychnine* is of great value in this condition, a thirtieth of a grain being given subcutaneously and repeated hourly for two or three doses; its action is often increased by the addition of a hundredth of a grain of *digitaline* to it. Under the combined influence of these drugs the pulse becomes much steadier, for a time at any rate, and the patient's condition improves. *Ammonium carbonate* (gr. ij-iij) or sal volatile (ʒss) may be given hourly. Everything must be done to keep the patient alive for a few hours until the poison in the blood can be excreted.

When the toxæmia is profound, saline infusion is of the greatest value in diluting and helping the excretion of toxins and in keeping up the blood-pressure. When the bowels are not irritable, this is best given by the drop method described in speaking of shock (see p. 115). When this plan is not feasible, about fifteen ounces of the saline solution may be injected into the axilla (in an adult) every hour until the patient improves or is obviously moribund.

Vomiting is a very distressing feature in some cases, and, should it persist, simple effervescing mixtures, such as effervescing citrate of caffeine, in teaspoonful doses will often check it: a mixture containing five minims of dilute hydrocyanic acid with a drachm of liquor bismuthi, or fifteen grains of carbonate of bismuth suspended in mucilage, to the ounce of water, is also often useful. When recovery is taking place, the patient should be encouraged to drink large quantities of fluid so as to dilute the poison, and it is well to use the 'imperial drink' referred to on p. 15, which is also a diuretic. When convalescence is established, a liberal diet must be ordered and tonics administered. When the wound has granulated, further danger from this particular form of septic absorption disappears.

TRAUMATIC FEVER.

As long as the organisms that have gained access to a wound remain limited to the fluids or dead tissues in it, or are purely saprophytic in nature, they are only capable of giving rise to a condition of septic intoxication pure and simple. Should any of the organisms producing this septic intoxication be capable of parasitic growth, however, and should they gain entrance to the living tissues of a wound of any size, the condition known as traumatic fever arises. This is due partly to absorption of the products of saprophytic growth in the wound, and partly also to the entrance of pyogenic organisms; it generally continues until the establishment of granulation and suppuration. When it occurs, the reactionary pyrexia which often follows aseptic operations runs up to 103° or 104° F. instead of abating, and then falls slowly in an intermittent manner, until the fourth or fifth day, when it falls rapidly, the final descent coinciding with the complete establishment of granulation. Traumatic fever does not usually prove fatal, unless it end in septicæmia or pyæmia; suppuration always occurs in the wound, however, and attention must be specially directed to the local condition.

TREATMENT.—As soon as traumatic fever sets in, the wound must be dressed, and efficient *drainage* established. When no drainage has been employed, the wound should be thoroughly opened up and large tubes inserted. When tubes have been inserted at the time of operation, the wound should be washed out with warm sterilised saline solution, with the object of getting rid of decomposing clots. This should be done at the first dressing, but should not be repeated; washing out a wound injures the delicate granulation-tissue without killing the organisms which, being of the ordinary pyogenic variety, have already penetrated into the tissues. The injury done to the granulations by irrigation of a wound may enable the organisms to penetrate more freely into the body and set up septicæmia or pyæmia.

The antiseptic dressings should be changed daily, and the surgeon must wait until he sees whether the condition merely ends in suppuration, or whether some more serious complication is going to arise. When the case ends in suppuration, the temperature falls about the fourth or fifth day, and the patient soon recovers.

The diet should be somewhat restricted, and it is well to avoid the use of stimulants, or at any rate to give them only in very small quantities unless the temperature be high and the general condition bad; during the acute sthenic stage of inflammatory fever they are not really called for. The patient should take plenty of 'imperial drink' (see p. 15), so as to keep the kidneys active; the bowels should be kept open with mild saline aperients such as Seidlitz powders or drachm doses of sulphate of magnesia or effervescing sulphate of soda, combined with enemata.

ACUTE SEPTICÆMIA.

This condition is much more serious than the one just described. Like it, acute septicæmia is also due to the pyogenic organisms, but the exact pathology is not very clear. It is sufficient for our purpose to point out that the affection is essentially one of poisoning by chemical products. The organisms themselves are not met with free in the blood in any large numbers, and they probably establish themselves either in the wound or in some of the internal organs, whence they pour septic products into the blood. Although the condition resembles that of septic intoxication in being due to chemical poisoning, it differs from it both by being caused exclusively by parasitic organisms, and by the fact that these latter have gained a footing either in the living tissues of the wound or in the internal organs. Acute septicæmia follows traumatic fever when the latter does not end favourably.

SYMPTOMS.—These usually begin before the traumatic fever has subsided. The temperature, which has begun to fall, rises again to 103° or 104° F. and remains high, but shows slight morning remissions of about a degree. Rigors are rare, but the patient feels ill and at first presents all the signs of sthenic inflammatory fever; in bad cases he soon passes into the typhoid state. Vomiting is not uncommon, and sometimes diarrhœa is present, though more commonly there is constipation. The urine frequently contains albumin, the wound is usually swollen and painful, and the discharge from it is diminished or even arrested completely. The disease is very fatal; only a small number of those attacked recover.

Treatment.—This is mainly directed to the symptoms; but when examination of the discharges from the wound shows the presence of the streptococcus pyogenes, antistreptococcic serum should be injected (see p. 173). Vaccines are often employed, but their use is not devoid of danger (see Appendix). Usually, however, there is nothing to be done but to employ constitutional treatment, in the hope that the tissues may conquer in the fight against the organisms. A generous diet should be given, and free stimulation will be necessary as soon as the pulse begins to fail. If the temperature remains over 103° F., tepid sponging or some of the other antipyretic measures recommended on p. 194 should be adopted. Ten grains of quinine should be given every four hours for twenty-four or forty-eight hours even in spite of symptoms of cinchonism. The object is to get a bactericidal effect; this can only be done by practically poisoning the patient with the drug, which is then discontinued for twenty-four hours and drachm doses of Warburg's tincture every four hours substituted. This plan is sometimes very satisfactory. The bowels and the kidneys should be kept acting freely.

The wound should always be opened up and drained freely, but at this stage there is no chance of really disinfecting it or of preventing the entrance of organisms into the body. When the wound is in one of the extremities, amputation has been done in a considerable number of cases; but unfortunately, this has little effect on the progress of the disease, for in most cases the organisms seem to be established in the internal organs, and the only result of amputation is to lower the patient's vitality and hasten the fatal result. Unless the source of the general condition be definitely limited to the wound or its vicinity, amputation is worse than useless.

CHRONIC SEPTICÆMIA OR HECTIC FEVER.

The condition known as hectic fever is really a chronic septicæmia; it may follow the acute form in a few rare cases, but is generally chronic from the first. It is marked by pyrexia, night sweats, wasting, and dryness of the tongue, and usually does not come on until the chronic septicæmic condition has lasted for some weeks at least. The temperature has a distinctly hectic character, being high in the evening (101° or 102° F.) and falling to about normal in the morning. The same intermittent type of pyrexia is also seen in acute septicæmia, but there the temperature is always a febrile one, notwithstanding the morning fall. The condition used to be ascribed to the loss of certain constituents of the blood as a result of prolonged suppuration. There can be no doubt, however, that it is due to the action of pyogenic organisms, which apparently do not grow in the blood and the viscera, as they probably do in acute septicæmia, but are located mainly in the wound. After hectic fever has lasted for some time, a peculiar degeneration of the blood-vessels, termed *waxy degeneration* or *lardaceous disease*, takes place, and this chiefly affects the blood-vessels in the liver, the kidneys, and the intestines; as a result of this there is polyuria, albuminuria, diarrhœa, and œdema of the extremities. The waxy degeneration is due to the direct action of the poisonous bacterial products circulating in the blood upon the walls of the blood-vessels; it is not due to the loss of the purulent fluid, as was formerly supposed. The affection is most frequently met with in association with tuberculous disease or necrosis; it was formerly a common sequela of operations upon psoas and other spinal abscesses, and was the actual cause of death in a large number of those cases.

TREATMENT.—**Local.**—The question of disinfecting the wound and getting rid of the source of the disease is naturally the first to arise.

From this point of view, the cases may be divided into two large groups: those in which the focus of the disease can be removed entirely, and those in which this is impossible.

When the Focus of Disease can be removed entirely.—These cases may be subdivided further into those in which some local operation is sufficient to get rid of the primary disease, and those in which amputation is necessary.

Local operations, such as the removal of a sequestrum or clearing out of a joint, are called for when the extent of the primary disease and the anatomical conditions of the part are such as to offer a good chance of removing the cause of the mischief completely and ensuring thorough disinfection of the tissues. In such cases the whole extent of the wound should be opened up, and left open, after either excising the focus of the disease completely, or scraping it out and sponging it with undiluted carbolic acid; all the recesses of the wound should then be packed with cyanide gauze sprinkled with iodoform. The outside dressing should consist of cyanide gauze and salicylic wool, and both it and the packing should be renewed daily.

Amputation is called for: (α) when the primary focus can *only* be removed by amputating the limb, and (β) when amputation is the *only safe* method of attaining that end.

Perhaps the most familiar cases in which amputation is obviously the only means of eradicating the primary trouble are those of extensive disease—generally tuberculous—of the knee, ankle, elbow, or wrist joints, accompanied by widespread suppuration and septic sinuses; any partial operation is powerless to arrest it, and nothing but an amputation performed through healthy parts will avail.

Sometimes amputation is the *only safe* method of treatment even when the local disease is small in extent. Should the changes consequent upon the occurrence of hectic fever be so far advanced that the patient is completely worn out, little good will be gained by any partial operation. Quite apart from the question of the deleterious effects of the shock and loss of blood, which are often considerable in an attempt to remove the diseased parts by dissection, the patient's condition is such that he cannot bear the strain of a prolonged period of healing, and amputation therefore offers the only chance. Although the presence of waxy degeneration of the kidneys was supposed formerly to be a bar to amputation, we find now that this is not so in an amputation performed antiseptically; not only does the hectic fever subside after amputation, but the waxy condition of the organs tends to improve, the liver diminishes in size, the albumin becomes less, and may ultimately disappear. Therefore amputation is clearly indicated, both with the view of saving the patient's life and of arresting the progress of the disease.

When the Local Disease cannot be removed entirely.—The greatest difficulty occurs when the source of infection is on the trunk—as, for example, in psoas abscess. In these cases it is impossible to remove the source of infection entirely, but nevertheless the only chance for the patient is to render it as little virulent as possible. The best thing is to scrape and wash out the wound thoroughly with Barker's flushing spoon (see Fig. 52) and 1 in 6000 sublimate solution, and then to fill it with iodoform and glycerine emulsion as recommended for chronic abscess (see Chap. XII.), or to use the bismuth mixture referred to in connection with sinuses associated with tuberculous disease of bone (see Vol. II.).

Another example in which treatment is very difficult is tuberculous hip-joint disease in which the pelvis is extensively involved. Here the best thing probably is to perform amputation at the hip joint, which serves the double purpose of removing a considerable portion of the diseased tissues and allowing free access to the mischief in the pelvis. The disease may be completely arrested by careful removal of as much of the affected parts as possible, followed by disinfection and free drainage of the wound. When hectic fever results from long-standing empyema, it may be cured by bringing about closure of the wound by Estlander's operation (see Empyema).

General.—The patient's strength must be supported by nourishing food, fresh air, and good hygienic conditions. Tonics, such as iron and quinine, will be useful, and stimulants should be given if necessary.

ACUTE PYÆMIA.

Pyæmia is the gravest of the infective diseases of wounds ; it usually comes on from a week to ten days after an operation or injury. The traumatic fever has generally passed off, and the temperature has nearly reached the normal, when the patient suddenly has a rigor, which may last from twenty to forty minutes. The temperature immediately rises to 103° or 104° F., remains at that point for perhaps half an hour or more, and then begins to fall, while, coincident with the fall, there is profuse sweating. The phenomena of pyæmia thus closely resemble those of ague : there is first the cold stage, then the hot one, and finally the sweating. The temperature may fall in a few hours after the attack to what it was before the onset of the rigor, or even to normal, and for a day or two the patient may seem fairly well. Then there is another rigor, the same series of phenomena recurs, and so the case progresses, with constantly recurring rigors, the intervals between which steadily diminish, while the temperature in the intervals does not fall as low as before. The patient often becomes jaundiced, and signs of abscesses in the lung, joints, etc., manifest themselves, albuminuria develops, and death generally occurs about eight or ten days after the first onset of the disease.

Although it is probable that acute pyæmia is due essentially to the same organisms as those that cause septicæmia, the two affections differ widely, not only in their clinical characters, but also in the pathological changes met with. From the point of view of treatment, the pathological condition in pyæmia is extremely important. The disease is undoubtedly due to the pyogenic organisms, the one most frequently found being the streptococcus pyogenes. The lesions found after death are abscesses in various organs, and suppuration in connection with various serous membranes; the abscesses are most numerous in the lung in the majority of cases, or in the liver if the wound be in connection with the bowel. The pathology of pyæmia is apparently that a vein in the neighbourhood of the wound becomes inflamed and thrombosed in the first place, and then organisms grow in the thrombus and cause it to break up gradually. Small portions containing virulent organisms are carried on in the blood-stream and become impacted in the lungs when the thrombosis is in one of the systemic veins, or in the liver when the primary source of the mischief is in the portal area. Here probably the same process is repeated, and emboli are again given off and distributed by the arterial circulation, lodging in the kidney, the spleen, the synovial or the serous membranes, etc., where they give rise to abscesses. These secondary abscesses may also be caused by the growth of streptococci floating free in the blood; the cocci form long chains which coil up into masses which are unable to pass through the smaller vessels, in which therefore they become impacted. The most important point with respect to treatment is that the disease is generally associated with thrombosis of a vein, and is due to detachment of portions of clot from the blocked vessel. Therefore, the disease is essentially a local one, in its earlier stages at any rate, and can be effectively treated by appropriate local measures.

TREATMENT.—Local.—The first point is to search for a thrombosed vein; in the extremities this will probably be the main vein of the limb. If there be a tender, inflamed, and blocked vein in the neighbourhood of the wound, it should be cut down upon and traced upwards to a point where it is still patent; a double ligature is put on it there, and the vein divided between. It is also advisable to dissect out the thrombosed vein and any of its communicating branches which may be similarly affected, if this can be done. If this be done when the patient has only had one or two rigors, the disease may be arrested completely; a good example of what can be done by this method of treatment is seen in pyæmia following thrombosis of the lateral sinus due to otitis media.

Besides removal of the thrombosed vein, which is the most important part of the treatment, and the only one that promises anything like a radical cure, there are various other points that should be attended to. The wound should be thoroughly opened up, the pus washed away, the surface sponged with undiluted carbolic acid, and the granulations scraped away whether the vein has been removed or not. It is well to sponge the granulations with undiluted carbolic acid before scraping them away, so as to get rid of organisms lying upon the surface which might be carried by the sharp spoon into the deeper tissues; after the granulations have been removed, the raw surface left should be swabbed over again with the undiluted acid. The wound should then be packed with cyanide gauze sprinkled with iodoform, or with iodoform gauze, and a gauze and wool dressing applied outside. The packing is renewed daily at first, and then at longer intervals, if the case does well. When a fresh layer of granulations has sprung up, the packing may be discontinued, a large drainage-tube placed in the wound so as to make sure that the discharge escapes freely, and a stitch or two inserted when the wound is large. If the patient survive, and external abscesses develop, they must be opened early and drained freely. When suppuration occurs in joints, the latter must be opened freely and drained efficiently; this point is dealt with fully in connection with the affections of joints. Further details as to local treatment in special cases will be found in connection with pyæmia after acute osteomyelitis.

When there is no wound, and the pyæmia has started from a suppurative periphlebitis, the vein must be exposed well on the proximal side of the thrombus as far from the affected spot as is judicious, tied in two places, and divided between the ligatures. An incision must then be made over the seat of the inflammation, the pus around the vein evacuated, and the part containing the thrombus excised, a ligature being placed on the distal portion of the vein. If it be impossible to excise the vein, it should be opened, and the clot removed by scraping and irrigation, the wound being then packed with gauze wrung out of an antiseptic (1 in 2000 perchloride of mercury). Any branch that is patent should be also ligatured and divided. It is very important not to be content with simply tying the main vein, because the septic clot may spread to other veins and thus get into the circulation again.

General.—Amongst *drugs*, the greatest reliance is placed on quinine. In most cases it is well to begin with fifteen to twenty grains of sulphate of quinine, and to follow it up after four hours with five- to ten-grain doses every four hours, for twenty-four to forty-eight hours, in spite of symptoms of cinchonism. Salicylate of soda (twenty grains every three hours) may also be used, but the patient should be watched for signs of salicylate poisoning. Sulpho-carbolates have been suggested with the idea that carbolic acid would be liberated in the blood, and would help to destroy the organisms there; as a matter of fact, however, the amount of carbolic acid that could be thus liberated would have no effect, and in practice the sulpho-carbolates are useless.

Antipyretic measures must be employed when the temperature is unusually high, because the patient may die of the hyperpyrexia after a rigor. Phenacetin in five- or ten-grain doses is perhaps the safest of the antipyretic drugs, and it may be repeated every hour if necessary, the pulse being watched meanwhile for any sign of depression. Antipyrin is no doubt a still more effectual antipyretic, but it is a powerful depressant, and may produce an alarming degree of collapse if the patient be weakly. Sponging the body with water at about 90° F. is a rapid and effectual way of reducing the temperature; it is agreeable, and not depressing. The patient should lie naked between blankets, and the sponging should be done under the blanket without exposing the surface of the body to the cold air; it should be continued for about fifteen minutes, and the skin should be then dried with soft towels. Care must be taken to maintain the temperature of the water used for sponging. Sponging should be repeated whenever the temperature rises above 102° F. Rectal saline injections administered by the drop method (see p. 115) are often of great value.

Stimulants will also be necessary, but they should not be pushed to extremes, in the early stage at any rate; about six ounces of brandy should be given in the twenty-four hours. A larger quantity may be required at a later period, when champagne is specially useful given with or immediately after food.

A liquid *diet* should be given; solids only accumulate in the intestines and upset the digestive organs. Milk (which may be combined with a few drops of saccharated lime water to prevent curdling, or with sodium citrate gr. j ad ℥j) and meat juices should be given in small quantities frequently repeated. About four pints of milk and a pint and a-half of strong beef tea should be given in the twenty-four hours, with a teaspoonful of meat juice every four hours. Citric acid and citrates are also of value.

The question of vaccines in acute pyæmia is dealt with in the Appendix. Though they are sometimes of value, the dose must be determined very carefully, for if this be too large much harm may be done.

CHRONIC PYÆMIA.

Besides the acute form of pyæmia described above, there are various chronic types which are associated with other organisms, particularly the pneumococcus. It often happens that, although repeated abscesses form and the disease is very protracted, the internal organs remain free from infection; this form is termed external pyæmia. There may also be a remarkable restriction of the infection in some cases to one type of tissue; for example, a primary abscess in a joint may be followed by secondary abscesses in other joints, the bone and subcutaneous tissues remaining healthy, while in other cases the skin only is affected and there may be a large number of abscesses in the skin and subcutaneous tissue without any infection of bone, joints, or viscera. Secondary abscesses may follow immediately upon the primary one, or there may be a quiescent interval between them; this condition is most commonly met with in children.

TREATMENT.—Any external abscess will require to be opened. Any joint that becomes infected must be fixed upon a splint, opened freely, and a drainage-tube inserted. The patient is usually not in a condition to bear any more severe procedure, but free drainage of the joint often suffices; in these successful cases the patient may even recover the full movements of the joint. The injection of *antistreptococcic serum* has been tried in these cases, but it is difficult to say much about its value. If it be used, full doses should be given twice a day for three or four days (see p. 173). These cases are, however, much more suitable for treatment by vaccines (see Appendix) than by serum.

ERYSIPELAS.

Erysipelas is a febrile disease caused by a streptococcus, and characterised by a well-defined spreading redness of the skin.

SYMPTOMS.—The disease usually commences from four days to a week after the operation or injury, but it may occur as early as the first or the second day.

The wound through which the organisms gain entrance to the lymphatics need not be extensive; it is often a mere prick with an infected instrument, or an insect bite, and may have healed completely before the onset of the disease.

There are usually certain premonitory symptoms preceding the actual attack, such as malaise, headache, loss of appetite, and a feeling of tension and pain about the wound; this may be followed by a rigor. In other cases the disease may begin suddenly with a severe rigor, without any premonitory symptoms. However it may be ushered in, the attack is followed by a rapid rise of temperature to about 104° F., headache, nausea or vomiting, a rapid soft pulse, a foul tongue, great thirst, scanty urine, diminution of the discharge from the wound, and swelling of the neighbouring lymphatic glands, to which there may be red lines running from the wound. Occasionally there is active delirium. In from ten to twenty-four hours after the rigor a dark red or crimson blush, which is sharply marked off from the surrounding parts, appears around the wound, and the reddened portion is somewhat swollen. The redness increases and usually spreads along the course of the lymphatic vessels—that is to say, towards the trunk. The margin of the rash can be felt as a distinct raised ridge. Where the tissues are lax, as in the eyelids or the scrotum, the swelling may be very great, and bullæ may form upon the surface; bullæ may also appear, although not so frequently, when the trunk or limbs are affected. During the course of the disease there is often albuminuria. In about six or eight days there is generally a rapid fall of the temperature, which has remained high during the acute period. The constitutional phenomena disappear, the appetite improves, the redness gradually fades, and usually dies away by the middle of the second week; finally desquamation occurs. This desquamation is of great importance, because it is in the scales of epidermis that the chief source of the erysipelas infection is to be found. After recovery recrudescence of the disease is common. In bad cases the disease may end fatally during the second week from pyrexia and general exhaustion.

VARIETIES.—This disease is seldom seen nowadays, and the form usually met with is the mild one which ends in recovery. In one type the disease reappears frequently but with ever-decreasing constitutional disturbance; this is sometimes spoken of as habitual erysipelas. Formerly a number of other varieties were described, such as wandering erysipelas in which a patch of erysipelas appeared at one spot, and died away, and fresh patches appeared elsewhere, constitutional symptoms showing themselves as each fresh patch appeared. The most serious forms were described as phlegmonous and gangrenous erysipelas; in these, in addition to the symptoms already described, there was suppuration in the subcutaneous tissues, which sometimes took the form of an abscess, but more commonly manifested itself as a diffuse cellulitis; occasionally the skin and the deeper tissues sloughed. In these cases the patient soon passed into a typhoid state, and often died.

It is a question whether these gangrenous and phlegmonous varieties of erysipelas are due solely to the erysipelas organism, or whether there is a mixed infection, the erysipelas organism growing in the skin, and the streptococcus pyogenes in the deeper structures. The majority of investigators incline to the opinion that the streptococcus pyogenes and the erysipelas organism are identical and are only slightly modified in virulence; according to this theory, phlegmonous erysipelas is regarded as a more virulent form than the one commonly seen nowadays. In favour of the theory of a mixed infection is the fact that diffuse cellulitis may occur without cutaneous erysipelas, and *vice versâ*; besides this, there are points in the bacteriological history of the organisms which seem to indicate a distinct though slight difference.

Pathology.—The streptococcus which causes the disease spreads in the cutaneous lymphatic vessels, and is found in the skin immediately beyond the edge of the blush; the organisms are always a little in advance of the visible disease. At the edge of the blush the lymphatic vessels are found full of micrococci and of leucocytes, while nearer the centre of the redness the micrococci have disappeared and only leucocytes are found. Erysipelas therefore presents one of the best examples of phagocytosis, the phagocytes attacking and destroying the organisms and putting a stop to their action. This view may possibly help to explain the results of treatment.

TREATMENT.—The **prophylaxis** is extremely important, and, as erysipelas is never met with in aseptic wounds, it is of the utmost importance to secure the asepsis of all wounds.

General.—The mild form usually met with nowadays generally subsides spontaneously. Provided that there be no internal complication, such as visceral disease, it suffices to administer a saline purgative (sulphate of magnesia ℥ij-iv) and to see that the bowels are afterwards kept open daily with drachm doses of the same drug in warm water the first thing in the morning. A pleasant aperient is effervescing sulphate of soda (ʒj), or a Seidlitz powder. Quinine (gr. j-ij) every four hours and tincture of perchloride of iron (♏xv in water) every three hours are looked upon as being of special value. The diet should consist of milk, beef tea, or strong soups.

Local.—In the more severe forms of erysipelas it is important to make the most strenuous efforts to check the local progress of the disease. In former days a favourite plan was to draw a line on the skin around and just in front of the area of the redness with solid *nitrate of silver*, or to paint on liniment of *iodine* in a similar manner, and it was found that the erysipelas stopped at this line in a certain number of cases and seemed unable to cross it. At first sight this treatment does not seem very rational, but if we bear in mind what has just been said as to the relation of erysipelas to phagocytosis it becomes explicable and logical. If the skin be irritated with nitrate of silver or strong iodine, increased leucocytosis will occur in the part, and if this be done a day or two before the erysipelas organisms reach the area to which the irritant has been applied, they will find the tissues and vessels blocked with large numbers of leucocytes, the phagocytic action of which may suffice to prevent their further spread. It seems probable that one reason why this method did not succeed uniformly is that the application was not always made sufficiently early or far enough away from the spreading margin to ensure an adequate leucocytosis in the part before the organisms reached it. The method may be of value if care be taken to apply the irritant very thoroughly at some considerable distance from the edge of the redness. Kraske's method, which at the present time seems to promise best, probably acts on the same principle.

Kraske's method consists in making numerous small scarifications in the skin at some distance beyond the spreading edge of the erysipelas, just deep enough to draw blood. The scarifications should be very numerous, and should cross each other and surround the entire reddened area about two inches from its edge (see Fig. 56); after oozing has ceased, the affected area is either soaked or sprayed with a 1 in 20 carbolic acid solution for an hour. Then compresses of gauze soaked in 1 in 40 carbolic acid solution are applied over the scarified surface. Partly as the result of the scarifications and partly as the result of the carbolic acid, considerable irritation is produced all round the erysipelatous area, and, as suggested above, when the organisms reach the irritated part they are met by a barrier of cells. Certainly experience seems to show that Kraske's method is the most effectual plan of treating erysipelas, so long as the affection is a true cutaneous one and does not involve the subcutaneous tissues as well. It should only be used in severe cases, however, as it is painful, and an anæsthetic is required during the scarification.

Among the many applications to the actual erysipelatous area advocated by various authorities, perhaps the best is ichthyol, which can be applied in watery solution (10 to 25 per cent.). Some surgeons state that they have got good results by spraying the affected area freely with *carbolic acid*, upon the presumption that the acid is absorbed by the lymphatic vessels, and thus directly affects the organisms; probably this idea has no good foundation in fact. In most cases applications calculated to relieve the local discomfort are sufficient. When there is neither much heat nor pain, all that is necessary is to wrap the part up in salicylic wool. When both pain and swelling are present, *lead lotion* or lead and opium lotion (see p. 9) is to be recommended; lint kept constantly moist with the lotion should be placed over the affected area. During desquamation it is well to keep the part anointed with some antiseptic ointment, such as the ung. eucalypti. This relieves the troublesome itching often complained of, and lessens the chance of dissemination of the infective epidermic scales.

FIG. 56.—KRASKE'S TREATMENT FOR ERYSIPELAS.—There should be a clear interval of two inches between the ring of scarifications and the margin of the rash.

In a case of the so-called phlegmonous or gangrenous erysipelas, the treatment is identical with that of diffuse cellulitis (see p. 31). *Free incisions* should be made into the part in all directions so as to allow the escape of the discharge, and this should be followed by *constant irrigation* (see p. 32).

The advisability of using *antistreptococcic serum* in this affection must also be borne in mind; so far the results obtained from it have not been encouraging. At the same time, it does not seem to do any harm, and therefore any of the forms of treatment mentioned above may well be accompanied by the injection of 20 c.c. of the serum at present supplied by the Lister Institute of Preventive Medicine; half that quantity should be given again in twelve hours, while a third dose may be given twelve hours later (see also p. 173).

TETANUS.

Tetanus is an infective disease of wounds due to a special bacillus and characterised by painful tonic contractions of the muscles with convulsive exacerbations; the contractions commence in the muscles of the jaw and neck, and spread to all the voluntary muscles of the body.

SYMPTOMS.—The affection usually begins between the fifth and fifteenth day after the infliction of the wound. Preceding the onset of the disease, there are often *prodromata*, such as a feeling of malaise, a tendency to yawn, headache, fear on the part of the patient that he will not get better, and neuralgic pains in the wound radiating along the nerves and accompanied by local spasms or cramps.

Shortly after the appearance of these premonitory symptoms the typical symptoms of tetanus set in; the muscles of mastication are generally affected first and the condition known as *trismus* is produced. The masticators contract and more or less fix the jaw, and convulsive contractions of these muscles occur on any attempt to open the mouth to eat or drink. The spasm next attacks the muscles of the neck, resulting in fixation of the head, and about the same time the muscles of expression also become affected, giving rise to the *risus sardonicus*, in which the angles of the mouth are drawn out, the alæ of the nose elevated. the eyes widely opened, and the forehead wrinkled. The next set of muscles affected is generally the pharyngeal group, leading to spasmodic dysphagia. Soon the voluntary muscles elsewhere are attacked, generally in groups, those next affected being usually the sacro-lumbar muscles and those of the lower extremities, leading to *opisthotonos*; then the muscles of the upper extremity, those of the abdomen, and, fortunately last of all, the muscles of respiration. The muscular spasm seldom relaxes altogether, while the least movement or disturbance of the patient is apt to set up clonic contractions—the well-known tetanic spasms. The pulse generally varies from 100 to 140; the temperature is usually up to 104° F., being highest during the convulsions. When the temperature goes higher than 104° or 105° the condition is generally very grave, and the pyrexia may end fatally unless steps be taken to reduce it. The respirations are normal, but increase in frequency during the attack; the patient cannot swallow, the saliva runs out of the mouth, there is diminution in the amount of the urine but no albuminuria, and there is profuse sweating after the convulsions.

The principal causes of death in this disease are: severe laryngeal spasm, terminating in fatal asphyxia, spasm of the diaphragm or other respiratory muscles, arrest of the heart's action due to spasm or paralysis, profound exhaustion and inanition, and hyperpyrexia.

VARIETIES.—Tetanus may be acute or chronic. The **acute** form accompanied by high temperature usually ends fatally in four days, and only about one per cent. of those affected with this form recover under ordinary treatment. In the more **chronic** variety the onset is more delayed, and the characteristic symptoms of the disease may not become manifest for two or three weeks; the convulsions are less frequent, and not so general. This form may become acute, however, and death then takes place rapidly; about twenty per cent. of the patients recover.

CAUSES.—Tetanus most commonly occurs after wounds of the extremities. It is due to a bacillus which is anaërobic and spore-bearing, and which is commonly found in garden earth, in horse-dung, and generally in places soiled with the latter. The reason why it occurs especially after wounds in the extremities is that they are more likely to be soiled; although tetanus most frequently occurs as a complication of lacerated wounds, it may follow a mere scratch. It is not the amount of laceration of a wound that is of consequence, but the soiling of it with earth. No doubt the soiling is more likely to be great when the wound is torn than when it is simply a clean incision. In infants infection may take place through the umbilical cord—'tetanus neonatorum.'

TREATMENT.—**Prophylactic.**—As tetanus is unknown in aseptic wounds, it is clear that strict purification of wounds likely to be infected with the tetanus bacillus must be of the first importance. Hence all wounds that are soiled with earth, or that have occurred from falls in stables, gardens, and so forth, must be thoroughly purified, a nail-brush being used to scrub away the earth, and the whole wound thoroughly sponged with undiluted carbolic acid. (For further details see p. 171.) Moreover, since the symptoms of tetanus are really those of the late stage of the disease, when severe injury has been inflicted by the toxins upon the nervous system, it is well to administer 10–20 c.c. of anti-tetanic serum in any case in which there is reason to suspect that the wound may be infected with the bacillus, without waiting for the typical symptoms to develop. This avoids the risk of the nervous phenomena persisting after the tetanus toxin has been satisfactorily neutralised by the anti-tetanic serum.

Curative.—When the disease is established, *anti-tetanic serum* is undoubtedly effectual in a number of cases, and should be employed at once. It is the serum of horses, or other animals which have been rendered immune to tetanus, and is injected subcutaneously. It is well to begin with 20 c.c. of the serum prepared by the Lister Institute, and to repeat the dose in from twelve to twenty-four hours, according to its effect on the spasms. The administration should be repeated every twelve or twenty-four hours if necessary.

The failure which has often followed subcutaneous injection of the serum when the disease is well developed has led to the practice of injecting it into the central nervous system itself. The serum may be injected into the subarachnoid space by means of lumbar puncture, but the most certain method is to inject it into the substance of the cerebral hemisphere itself. This method is not as dangerous as it would at first sight appear; the cerebral tissue is comparatively loose, and in one case, which ended fatally, and in which 5 c.c. had been injected into the frontal lobe, no trace of the injection could be found *post-mortem*. It is well, however, to make the injection beneath a silent area of the cortex where destruction of a few fibres will lead to no symptoms. The administration of chloroform is no drawback, since it is often called for to allay the spasms.

The head is shaved, and a curved incision is made through the scalp in the frontal region, just within the line of the hair; a flap is turned down so as to allow a half-inch trephine hole to be cut in the skull. The circle of bone is removed, a hypodermic needle is pushed through the dura into the brain and 5 c.c. of the serum are injected slowly. The needle is withdrawn and the wound sutured without replacing the crown of bone ; a similar operation is then performed on the opposite side. The opening in the skull can be felt clearly through the scalp, and it is easy to give a second dose, should one be required, without re-opening the wound, by thrusting the needle through the skin into the brain. It is thus possible to bring the antitoxin into actual contact with the poisoned nerve-cells and in some cases with very satisfactory results. The effect of the serum is sometimes very remarkable, but it is not immediate, and in spite of its use the spasms may recur so severely as to require the administration of chloroform ; they are usually, however, at longer intervals and less severe.

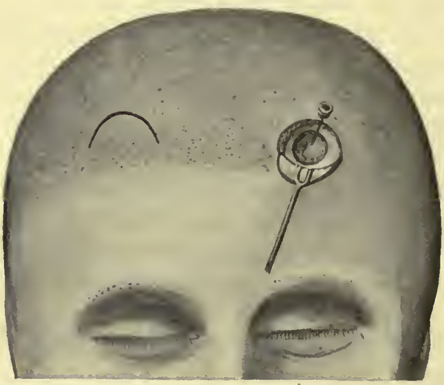


Fig. 57.—Intra-cerebral Injection of Anti-tetanic Serum.—On the left side the incision is shown ; on the right side the flap has been turned down, the circle of bone removed and the injecting needle thrust vertically through the dura mater.

Treatment of the Wound.—We do not know the exact *modus operandi* of the tetanus bacillus, though it is seldom limited to the wound; but nevertheless it is well in the early stage to give the patient chloroform, open up the wound and wash away all decomposing material, and then to clip away any gangrenous shreds, thoroughly sponge the wound out with pure carbolic acid, and pack it with cyanide gauze sprinkled with iodoform. The dressing then need not be disturbed for two or three days, so that the patient is saved the pain and the risk of convulsions involved in attention to the wound. Amputation is frequently performed in cases of wounds of the extremities, but, as the disease has generally established itself in the system, the operation is useless, and may be hurtful from the pain and disturbance it causes. If anything is to be effected by local treatment it will be done as effectually by thorough disinfection of the wound as by amputation, and with less risk to the patient.

Drugs.—Whether the serum be injected or not, it is necessary to administer sedatives, and the one most in vogue is *chloral* in large doses; an adult may have as much as 150 or even 200 grains in the course of twenty-four hours. Care must be taken not to poison the patient with the drug, as has undoubtedly happened, but usually the amount mentioned can be administered in the course of twenty-four hours without risk ; when there is inability to swallow, it may be administered by the rectum. Since the slightest noise or disturbance is likely to bring on a spasm, the patient should be completely isolated in a thickly carpeted room, and complete silence should be maintained ; it is well to wrap all the exposed portions of the body in cotton-wool, so as to avoid irritation to the surface of the skin from the impact of cold air, etc.

When the spasms are very severe and threaten to produce dangerous hyperpyrexia, or to cause death from obstruction to the respiration, *chloroform* should be administered. The spasm rapidly subsides under the influence of the anæsthetic, and repeated administrations may be called for in bad cases. When the patient is unable to swallow, advantage should be taken of the administration of the anæsthetic to introduce suitable nourishment into the stomach by means of a stomach-tube ; the opportunity may also be taken to give a nutrient enema. *Morphine*, in doses of one-sixth of a grain, may also be given subcutaneously every three or four hours ; but among drugs the chief reliance is to be placed on chloral and chloroform.

When hyperpyrexia occurs, the temperature should be reduced by sponging with tepid water or by cold wet packing. The former of these methods is preferable, as cold water is apt to set up a spasm. Should sponging fail to reduce the temperature, it will be necessary to have recourse to wet packing, which is done as follows. A mackintosh is put under the patient, who is then wrapped up in a sheet wrung out of iced water. A blanket is thrown over him and he is left in the wet pack for from five to fifteen minutes. Then the sheet and the mackintosh are removed, and the patient is dried and covered with the bedclothes.

Diet.—The strength should be kept up as far as possible by proper nourishment ; the great majority of cases in which the patient cannot swallow end fatally. If the patient cannot swallow, and especially if the attempts to do so produce convulsions, it is necessary to resort to rectal feeding ; care must be taken, however, to disturb the patient as little as possible in introducing the food into the rectum. For this purpose zyminised suppositories are of great value ; one should be introduced every four hours, and a two ounce beef-tea enema should be given every two hours after the suppository ; it is best to peptonise it before it is introduced. Later on in the disease, when the patient is becoming exhausted, it may be necessary to add stimulants to the enemata. Watch should be kept to see that the urine is passed, for the bladder is apt to become distended ; the bowel should be washed out with an injection of warm water from time to time. Above all things, care should be taken to avoid all sudden movements, and to be as gentle as possible in handling the patient.

CHAPTER X.

AFFECTIONS OF CICATRICES.

CHELOID.

ALTHOUGH the cicatrix is usually healthy when union by first intention has occurred, this is not invariably the case, and when a large wound has been allowed to heal by granulation, the scar left is often unsatisfactory. In either case the condition known as *false cheloid* or thickened cicatrix may be met with. The cicatrix becomes thickened and raised above the surface of the surrounding skin ; when the scar is linear there is a hard raised bar of this cheloid material, corresponding to the line of incision, and when it is a broad one the affection generally begins at the junction of the skin with the cicatricial tissue, and spreads thence through the rest of the scar. When the scar is broad, a most unsightly deformity is produced, as the surrounding parts are pulled upon and puckered up. The scar does not yield as ordinary scar tissue should, and the cheloid itself is painful, and liable to become ulcerated.

CAUSES.—The cause of this condition is by no means clear. Small cheloids are sometimes found on the back of the wrists, produced by the chafing of the patient's cuffs, and there is a type of cheloid found over the manubrium sterni—*Alibert's cheloid*—which does not seem to be associated with a wound. It is probable that slight sepsis is a factor in the production of cheloid in many cases ; for example, after operations in which slight infection has been suspected and a drainage-tube has been used, it is not uncommon to find a cheloid scar at the site of the drainage-tube, while that of the rest of the wound is quite supple. It is most common after operations on tuberculous patients, though there is no evidence that the affection is tuberculous, and in these patients it is not uncommon to find that every scar—even down to a pin- or needle-prick—becomes cheloid. The microscope reveals simply a large number of young cells and granulation-tissue.

Cheloid scars often disappear in the course of time, but such a termination is uncertain and cannot be confidently reckoned on.

TREATMENT.—The condition is excessively difficult to get rid of, and, as far as our present knowledge goes, it can neither be prevented nor can its occurrence be anticipated. When it is seen that it is about to occur—*i.e.* when the scar shows signs of thickening—an attempt may be made to diminish the vascularity of the part by *pressure*, exerted by strapping, by the application of collodion, or by a firm bandage. A very simple method is to paint the scar with ordinary (not flexile) collodion; this contracts as it dries, and diminishes the blood-supply of the scar by compressing the small vessels. This method may be of value in the early stage, but is not likely to do good when the cheloid condition is well developed. In applying pressure of any kind it should be borne in mind that ulceration is apt to occur in large cheloids, and its onset may even be sometimes precipitated by the application of collodion.

X-ray treatment of cheloid sometimes yields excellent results, but the sittings necessary to obtain this are numerous and the treatment is consequently tedious and expensive.

Fibrolysin (thiosinamin salicylate) is now extensively used, 2–3 c.c. of the solution prepared by Merck being injected intramuscularly once or twice a week. This method has drawbacks; it is slightly painful, and local indurated swellings, lasting for several weeks, often appear at the site of injection. Its use has been followed by rashes, and one case at least of fatal purpura has been reported. Against this it must be remembered that the drug has been in use for several years and the cases in which unpleasant or dangerous symptoms have followed are very few. It is possible that it should only be used in young subjects.

Cod liver oil (ʒj-iv) or one of its emulsions should be administered about four times a day. *Scarification* of the scar with a lancet or a fine electric cautery point has been practised, but it is doubtful whether any permanent benefit results from this.

The question of the advisability of *excising* a cheloid constantly arises and has been much debated; the great objection to excision is that the scar and the stitch marks resulting from it will almost certainly become cheloid in its turn. When a considerable area of skin has been excised, and there is so much tension on the stitches that they cut their way through the skin for some distance, a very unsightly appearance is presented should they become cheloid. At the same time it seems justifiable to remove the mass in certain cases even at the risk of linear cheloid subsequently resulting. For example, it is well to excise a broad ulcerating cheloid which gives rise to much contraction and great inconvenience, provided that the skin around is sufficiently lax to allow the edges to come together without marked tension after they have been undermined; the old broad scar is thus converted into a linear one. Owing to the tendency of the stitch marks to become cheloid, after an operation of this kind it is advisable to avoid the use of skin sutures entirely if that be possible ; buried sutures (see p. 137) should be employed, deep catgut stitches being inserted, through the subcutaneous tissue only, from the points where the undermining ceases on the one side to the corresponding points on the other, so as to relieve the tension on the skin edges, which are then approximated by stitches passing through the fat and the deeper parts of the skin, the actual margins being brought together by strips of gauze fixed on with collodion. A narrow cicatrix is thus obtained, and it is not a matter of great importance should this become cheloid ; sometimes the condition does not recur. When a large raw surface is left, it is better not to attempt to approximate the edges with sutures, but to skin-graft the entire wound instead (see p. 54). If this be done it will sometimes happen that there is no recurrence of the cheloid.

CONTRACTING CICATRIX.

This may be a very serious condition under certain circumstances. Even cicatrices resulting from healing by first intention sometimes contract so much as to cause a good deal of interference with movement. This is well seen when a thyroid tumour has been excised by a median vertical incision ; if the cicatrix contracts to any extent, a band is formed between the sternum and the larynx which interferes with extension of the head upon the trunk and often causes much inconvenience.

TREATMENT.—The cicatrix can often be divided transversely about its centre, the skin and cicatricial tissue undermined, and the divided ends of the scar pulled well asunder. It is then generally possible to bring together the lateral angles of the lozenge-shaped incision thus produced and so convert the transverse into a longitudinal wound, which is then stitched up and the scar thus elongated. When the surgeon has to do with a large cicatrix, as after burns, all tense bands should be divided in this manner, and the raw surface left after separation of the ends of the cicatrix grafted at once ; owing to the extent of the affected area it will not be possible to suture it in the manner just described. Other methods of dealing with the deformities caused by cicatrices in special situations are discussed under their proper headings.

PAINFUL CICATRIX.

Cicatrices are sometimes intensely tender, so that the slightest touch causes exquisite neuralgic pain which radiates from the scar. These painful scars occur most commonly when the edges of a wound have not been brought together accurately, but they may be met with even after healing by first intention ; they indicate the implication of nerves in the contracting scar-tissue.

TREATMENT.—The only satisfactory treatment is to dissect out the scar, cutting well into the healthy tissues at the sides, so as to remove not only the entangled nerve ends which may have already become bulbous, but also the adjacent and probably inflamed portions. When there is a broad scar and the edges of the wound cannot be brought together after excision, skin-grafting (see p. 54) or some suitable plastic operation is indicated.

ADHERENT CICATRIX.

A scar may be adherent to the tissues beneath, and may thus become a source of great trouble to the patient; besides which, these scars are often weak and ulcerate readily. For example, the scar resulting from a sore over the tibia may become fixed to the bone, and is then liable to undergo ulceration after injuries which would not affect it were it freely movable. The same is also the case with scars over the ends of bones after amputation; should they become adherent to the bone, the discomfort and pain they cause is extreme, and it is therefore one of the essentials of a good stump that the scar should not be adherent to the end of the bone.

TREATMENT.—In cases of adherent cicatrix after amputation, the obvious remedy is to open up the flaps, release the adhesions, and remove a slice of the bone, if necessary. When an ordinary scar is adherent to such structures as bones, tendons, or muscles, an attempt may be made to divide it with a tenotomy knife introduced through the skin at the margin of the scar. Generally, however, it is best to dissect out the scar altogether, and then to turn in a flap from the side so as to cover the raw surface thus made; the surface from which the flap is taken may be skin-grafted (see p. 54) if its edges cannot be brought together. This is preferable to grafting directly over bone, to which the grafts might in their turn become adherent. In some of these cases it has been suggested that sections of the underlying bone should be removed, so as to shorten the limb and relieve the tension on the wound left after excision of the scar, so that its edges can be brought together. Although this operation has been practised more than once, it can only be called for in extreme cases; the method just described will suffice for the majority.

EPITHELIOMA.

Scars which form adhesions to the deeper parts, or which are constantly in a state of irritation, are very apt to become the seat of malignant growths, more particularly epithelioma, as the patient gets older. Perhaps the most common seats of epitheliomata in the extremities are an old adherent scar, the orifice of a sinus, etc.; and this is a point which should be borne in mind in treating these conditions.

TREATMENT.—The treatment of epithelioma affecting scars is the same as the treatment of the disease elsewhere—namely, free excision of the diseased area and examination and, if necessary, excision of the nearest lymphatic glands. The exact nature of the operation will depend upon the situation and extent of the disease, but there should be no hesitation in removing it freely, even by amputation if necessary. Recurrence is less frequent after operation for epithelioma of the extremities than for epithelioma elsewhere, and this is partly due to the fact that there is plenty of room for wide removal of the disease.

DIVISION III.

SYPHILIS AND TUBERCULOSIS.

CHAPTER XI.

SYPHILIS.

Syphilis is an infective disease due to an organism discovered by Schaudinn and named by him the Spirochæta pallida. The disease may be *acquired*, usually as the result of impure sexual connection, or it may be contracted in utero; in the latter case it is called *congenital*.

ACQUIRED SYPHILIS.

Although syphilis is generally a venereal disease, extra-genital infection is well known, and may take place from direct contact with an infectious person or from some article which has been used by him. Syphilis is peculiar in that the manifestations of the disease vary with the lapse of time after infection, and hence it is usually described as having three stages. This division is convenient clinically, though there are theoretical objections to it. The disease has a distinct tendency to subside, especially under appropriate treatment. The earlier lesions are localised, superficial, symmetrical, and highly infectious, and are accompanied by constitutional symptoms, such as anæmia and often slight pyrexia at night. The later lesions are erratic in their distribution, and are less infectious, but may produce severe loss of tissue.

Primary Stage.—The first manifestation of acquired syphilis appears as an induration at the seat of inoculation, commonly termed a 'hard' or 'Hunterian' chancre, which generally undergoes ulceration. This induration arises at any time from ten days to eight weeks after infection; it most commonly occurs about the fourth week. It is followed by enlargement, first, of the nearest lymphatic glands, and subsequently of those in other parts of the body. The induration at the seat of inoculation and the enlargement of the nearest lymphatic glands are the phenomena usually included under the term 'Primary Syphilis.' In the male the chancre is usually situated in the fold between the prepuce and the glans, but may occur on either of these structures, on the frenum or even in the meatus. In the female it is most commonly inside the labia, and when small, the patient may be unaware of its existence. Extra-genital chancres are by no means uncommon. They occur on the lip, eyelid, tongue, tonsil, rectum, and cervix uteri; surgeons and obstetricians are liable to contract the disease when examining infected patients, and in them the sore is usually situated at the side of the finger-nail.

Syphilitic infection frequently co-exists with that of gonorrhœa, chancroid, or both. The presence of a soft sore often obscures the early diagnosis of syphilis, and these cases should always be kept under observation until the absence of induration and of secondary symptoms negatives the diagnosis of syphilis. In these cases serum diagnosis by the Wassermann reaction (see Appendix) is specially valuable, and the presence or absence of spirochætæ in the deeper parts of the chancre of course clinches the diagnosis. As regards the Wassermann reaction, it must be noted that it does not appear until some days, or even three or four weeks, have elapsed since the appearance of the sore. The primary chancre varies from a slight parchment-like induration, sometimes very difficult to recognise, to a deep sloughing ulceration or phagedenic chancre causing extensive loss of tissue. The severity of the disease corresponds to a certain extent to the severity of the primary sore.

Secondary Stage.—Following the primary condition, and usually commencing within three months after infection, a series of inflammatory phenomena occurs which affect the skin, mucous membranes, fibrous tissues, periosteum, etc., and these phenomena appear at intervals and are spread over a period of time, the length of which varies with the severity of the attack, but which lasts about two years on the average.

The onset of the secondary stage is marked by the appearance of general glandular enlargement. The glands are hard, rounded, and discrete; there is probably no specific liability of one set of glands to enlargement more than another, but the presence of enlarged supra-trochlear or sub-occipital glands without any obvious cause is always suggestive of syphilis. The early phenomena are usually the mildest and the most superficial, but the lesions become of a severer type and are more deeply seated as time goes on. During this period, which is spoken of as that of 'Secondary Syphilis,' are seen such affections as erythematous, papular, squamous, pustular, and nodular syphilides on the skin, and mucous patches or condylomata on the skin or mucous membranes. There is also frequently alopecia, due either to simple malnutrition of the hair caused by syphilis, or resulting from pustular syphilides of the scalp; in the former case it is temporary, the hair growing again as the patient recovers; in the latter, the loss of hair may be permanent. Periostitis may also occur, and may lead to permanent bony formations or nodes if it be left untreated. Iritis and other rarer affections are also met with in the secondary period. During the course of syphilis the general health is often markedly affected, especially during the early secondary period, when the patient becomes pale, weak, and cachectic, and the red blood corpuscles are diminished in number and lose a considerable proportion of their hæmoglobin. At this stage too there is often marked pyrexia.

Tertiary Stage.—Following the secondary stage come the phenomena spoken of as lesions of 'Tertiary Syphilis'; these may follow immediately upon those of the secondary stage, or they may occur before the latter reaches its termination. Usually, however, they do not appear until a considerable interval has elapsed, the patient having enjoyed many years of apparently perfect health in the meantime. They usually take the form of gummata or fibrosis in the various tissues and organs, or obstinate ulcerations of the skin or mucous membranes.

In the later stages of syphilis numerous affections of the central nervous system occur. These have been termed parasyphilitic lesions, as they are not accompanied with the formation of definite gummata. Locomotor ataxia and general paralysis of the insane are generally held to be of this nature.

TREATMENT.—From the point of view of *prophylaxis* it is well to enumerate some of the chief sources and modes of contagion of syphilis; the prophylaxis will obviously consist in avoiding them. The most common source of infection is perhaps the secretion from the primary sore, but a potent factor in the spread of the disease is the discharge from secondary lesions, such as mucous patches and condylomata; the blood also is infective during the secondary stage, and this infectivity is at its height when syphilitic manifestations are actually present. The usual mode of contagion is by sexual connection, but kissing is also a means of spreading the disease when secondary symptoms are present in the mouth or throat; in suckling also, infection may be conveyed from child to nurse or *vice versâ*. Simple sores on the fingers of medical men may also become inoculated; in the Jewish rite of circumcision infection has also occurred. Infection may be conveyed by vaccination, should the blood of a syphilitic infant contaminate the vaccine lymph; lastly, the disease may be communicated through the medium of infected utensils, such as cups, spoons, pipes, toys, etc., which have been used by those suffering from secondary syphilis.

When a person has been exposed to the risk of having the organisms deposited upon any part of the body, a careful disinfection of the area with a mercurial lotion should be carried out, followed by the application of a calomel ointment (25 to 50 per cent.). When a medical man is examining a case suspected to be syphilitic, the risk of infection can be minimised by wearing thin rubber gloves or by laying a square of gutta-percha tissue over the sore or ulcer that it is desired to examine, and palpating through that.

The treatment of the various lesions in the different tissues and organs, in so far as they call for special treatment, will be found in connection with affections of the particular organ or tissue. Here we shall only refer to the treatment of syphilis in general.

At the present time the whole question of the treatment of syphilis is under revision. If what Ehrlich hopes from the use of his new drug 'Salvarsan' or '606' be obtained, the treatment of syphilis by mercury and iodide of potassium will fall largely, if not entirely, into disuse. We have, however, thought it best to let these methods stand since the new compound has been only introduced so recently that a reliable and full judgment as to its merits cannot yet be formed. The immediate results that follow its use in all stages of the disease are most remarkable, but already several syphilographers are throwing grave doubts upon its efficacy; whether it be as a result of an insufficient dose, or of faulty administration, or from some other cause, some surgeons seem already to have had recurrences. All that we have seen so far has been most favourable to the drug, but longer time must be allowed to elapse before we can venture to give a definite opinion upon the many points involved in its use.

Our colleague, Dr. W. D'Este Emery, Pathologist to King's College Hospital, whose experience in the administration of the drug is considerable, has been good enough to furnish us with the subjoined account of the technique of the procedure.

The Treatment of Syphilis by 'Salvarsan' ('606').—The latest method for the treatment of syphilis consists in the use of an organic compound of arsenic, dioxydiamidoarsenobenzol, usually known by its trade-name of 'Salvarsan,' or more familiarly as '606.' This was introduced by Ehrlich after an exhaustive research into the action of many organic compounds of arsenic on animals infected with parasitic protozoa. It was hoped that it would act by destroying all the parasites in the body, effecting what Ehrlich terms the 'therapia magna sterilisans.' At the time of writing it is not quite certain whether this can be effected in all, or in a large proportion of cases—or how permanent the cures which it effects may be—but we have sufficient knowledge of its action to recognise it as the most potent therapeutic agent at our disposal. Its action is extremely rapid, and it often effects in a few days an amount of benefit which could only be hoped for after some weeks of careful mercurial treatment. Given with proper precautions in suitably selected cases, it appears to be devoid of any serious injurious effects. It is at present thought to be contra-indicated in elderly patients, and in patients suffering from advanced and serious internal organic disease, if not syphilitic in origin ; in cases in which the fundus oculi is not normal ; and especially, perhaps, in patients with advanced vascular degeneration. It should be said, however, that these precautions may be found in the future to err on the side of caution, and patients suffering from all of these conditions have been treated with the drug without mishap.

'Salvarsan' is a yellowish powder which is sold in glass bulbs exhausted of air and hermetically sealed. It dissolves in water or in normal saline solution, yielding a clear yellow solution which is highly acid in reaction.

Several methods of administering the substance are in vogue, of which the pleasantest for the patient and the most rapidly efficacious is the intravenous ; it is, however, perhaps a little the most difficult in application. The simplest method is that of Volk, who gives the powder freshly ground up with liquid paraffin and injects it under the skin of the back. This probably allows a more continuous action of the substance to occur, and may be used with advantage after an intravenous injection. Another method is that of Herxheimer, who triturates the powder with one-third of a cubic centimetre of 20 per cent. caustic soda, adds gradually 10 c.c. of distilled water, continuing to grind the whole together, and injects immediately. This is injected deeply into the muscle of the buttock. It is an effectual process, but is often so painful that it is not advisable to use it, if any other can be used.

Numerous forms of apparatus have been introduced for use in the intravenous method. The ordinary infusion used for saline infusions is supposed not to be sufficient, since some method is required by which no trace of the solution shall be injected into the tissues. To avoid this it is usual to employ a two-way canula by which normal saline solution can be injected first, then the solution, and, lastly, normal saline again. But if the technique here described be followed, no special apparatus is required and an ordinary infuser will answer very well. The author uses an apparatus (see Fig. 58) which presents the advantages of being cheap and portable, of being easily sterilised, and of allowing the solution to be filtered through a sterile filter-paper just before use. It consists of a glass bottle of, at least, 400 c.c. capacity (*a*), fitted as a wash-bottle, and having a funnel (*b*), the stem of which almost touches the bottom of the bottle, and a short tube passing just through the bung (*c*). To this is fitted about a yard of india-rubber tubing (*d*), which fits into a short length of glass tubing (*e*), which serves as a window. To this a needle (*g*), about as large as those used for antitoxin, or a little larger, is fitted by another short length of india-rubber tubing (*f*). A second bottle (*k*) of about the same capacity as the first is also required ; it should be plugged with cotton wool and should contain a few glass beads. To prepare the apparatus for use, 300 c.c. of normal saline solution made with distilled water (this is important) are placed in the bottle (*a*), and both it and the other bottle are sterilised in the autoclave ; a filter-paper must first be placed in the funnel (*b*), and it is advisable to protect it against subsequent infection by tying over it a sheet of cotton-wool. This is not to be removed until the apparatus is at the bedside. The solution must in all cases, be prepared fresh.

The process is as follows: First, pour about 30–40 c.c. of saline solution from bottle *a* to bottle *k*. Add the whole of the contents of one bulb of the drug (0·6 gram), and shake it gently until solution is complete; take care that none of the powder cakes on to the side of the bottle and escapes solution. This is less likely to occur if the glass balls be used, though

Fig. 58.—Apparatus for the Intra-venous Injection of 'Salvarsan.'
The technique is fully explained in the text.

they are not absolutely necessary. Now add cautiously from a hypodermic needle enough of a 15 per cent. solution of caustic soda to precipitate the substance and to re-dissolve it, again forming a clear yellow solution; the amount required is about 20 minims. Then pour the whole of the fluid remaining in bottle *a* to bottle *k*, and mix the two fluids. Lastly, filter the whole through the filter in the funnel *b* into the bottle *a*.

While the filtration is taking place, sterilise the skin of the antecubital fossa and apply a narrow bandage around the upper arm, so as to make the veins below it as prominent as possible, just as in the operation of venesection.

Filtration being complete, remove the filter-paper, and invert the bottle. The fluid will run down the tube *d*, and when it appears in the needle, the flow must be stopped by applying a clip or a pair of Spencer Wells's forceps to the short length of india-rubber tubing (*f*). It is important to make sure that all air has been got out of the tube, and that no solution remains in the point of the needle.

Push the point of the needle through the patient's skin about a

FIG. 59.—INTRA-VENOUS INFUSION OF 'SALVARSAN.' A shows the bottle lowered so as to produce a negative pressure in the needle, while in B it is raised so as to force the fluid into the vein.

quarter of an inch from the vein, and pointing upwards, and, when the bevel is completely buried, get the assistant who is holding the bottle to lower it, so as to bring it below the point where the needle has entered the skin (see Fig. 59, A). This creates a negative pressure in the needle, and when the latter is pushed onwards and enters the vein, blood immediately enters. This is recognised by watching the glass tube (*e*), and as soon as blood is seen in this the ligature must be loosed from the upper arm, and the bottle raised (see Fig. 59, B). The solution will now begin to flow into the vein, pushing the blood before it, and the process is allowed to go on until the desired amount is injected. (It is an advantage to have the bottle *a* marked in divisions of 50 c.c.; if this be done and if the bulb-full of the drug has been dissolved in 300 c.c. of normal saline solution as recommended, each division will correspond to 0·1 gram of the powder.)

When the requisite amount of the solution has run in, the bottle is again lowered until blood appears in the tube *e*. The needle is then slid quickly out of the vein, and an antiseptic pad applied for a few hours. The whole process should not take more than a quarter of an hour, exclusive of the preparation of the solution.

If an ordinary transfusion apparatus be used, the same device of lowering and raising the vessel will serve to avoid the injection of the solution into the tissues.

The operation is often followed by nausea and vomiting (which may usually be controlled by a mustard leaf to the epigastrium), diarrhœa, a temperature of 101° F. or more, and occasionally by pallor and syncope. In many cases, however, no untoward effects are seen, and in any case they are of short duration. There should be no local trouble if the injection be properly given.

In stout patients without prominent veins it may be necessary to expose the vein by dissection.

The doses usually recommended are 0·5 gram for a male adult, 0·4 for a female. The dose for a child is much smaller, certainly not more than 3 centigrams; and it is advisable, first, to treat the mother with the substance, and allow the child to take her milk, which has been found by Ehrlich and others to have a remarkable beneficent action.

When treated with an intravenous injection in this way, especially if followed up by a second in a day or two, or by an intramuscular injection, or by both, a chancre should heal up in ten days at most, sometimes in much less, and other syphilitic manifestations in a proportionate time. There should be abundant evidence of improvement in two or three days. Very often there is a local inflammatory reaction around the lesions, recalling a tuberculin reaction; such cases usually do well.

The Treatment of Syphilis by Mercury and the Iodides.—Unlike the foregoing method, the treatment by these drugs varies according to the stage in which the affection is when treatment is begun, and, therefore, we shall discuss it in relation to the three clinical stages of the disease—namely, primary, secondary, and tertiary syphilis. It is interesting to note that, although the division between secondary and tertiary syphilis is somewhat arbitrary, more particularly in respect to the time-limit, a further justification for this division is found in the fact that the two drugs which exercise a specific influence on the disease—namely, mercurial preparations and the iodides of potassium and sodium—act differently in the two stages. During the early secondary stage the iodides have little or no effect in causing the disappearance of the lesions, while mercury acts much more effectually. During the tertiary stage, on the other hand, the iodides are much more rapid in their action than is mercury.

The Local Treatment of Primary Syphilis.—In the local treatment of the sore irritating applications should be avoided. No attempt should be made to destroy the chancre by caustics; the application of a caustic never causes the disease to abort, and only produces extension of the ulceration. Excision of chancres is also not to be recommended as a general rule. In the great majority of cases the infection has spread far beyond the seat of inoculation by the time the diagnosis can be made with certainty, and there is no chance of cutting short the disease by removing the sore. During the early period, *when the diagnosis is uncertain,* frequent washings, followed by the application of half-strength boric ointment, or boric lint, should be relied upon. The parts should be kept as dry as possible and rest insisted on, especially in women. *When the diagnosis is certain,* the favourite local application is lotio nigra. The sore is washed with this three or four times daily, after which a piece of lint soaked in the lotion is applied over its surface. If the penis be the part affected, it should be kept in a bag made by sewing boric or salicylic wool between two layers of gauze; this prevents friction and avoids soiling of the linen. *When the sore is large and extending* it is well to dust it over with calomel and starch (calomel one part, starch powder three parts) two or three times a day, after drying its surface; when there is sloughing or when the discharge is offensive, one part of iodoform or iodol may be added to this. Lint dipped in lotio nigra is then applied to the surface of the ulcer. When the chancre begins to heal, the local use of mercurials may be given up and boric lotion and weak boric ointment substituted.

In the acutely spreading, so-called **phagedenic chancre,** it is well to bring the patient rapidly under the influence of mercury, especially if the chancre be in a situation where its spread may do serious harm. These so-called phagedenic chancres, although not true phagedena, are nevertheless often due to a mixed infection, and the rule as to the use of caustics may be relaxed here. When sloughing progresses actively in spite of the above treatment, the surface of the sore should be scraped so as to remove all the sloughs, and then undiluted carbolic acid applied to the raw surface; this may be followed by dusting with calomel and iodoform, and the internal administration of mercury. When the sore is small, it may be scraped with a sharp spoon, after application of an 8 per cent. solution of eucaine to its surface. If it be large, a general anæsthetic will be required, and the sore should be clipped away with scissors or destroyed by nitric acid (see p. 63). Boric fomentations are then applied until granulation is general, and before each fresh fomentation is put on the sore should be irrigated with a solution of peroxide of hydrogen (10 vols.).

At one time the question whether mercury should be given during the primary stage was much debated. The view very widely held was that it was not advisable to put the patient upon a mercurial course, since the diagnosis of syphilis at this stage was seldom beyond the possibility of a mistake, and the patient might thus be salivated or submitted to a tedious and prolonged course of mercury unnecessarily. The diagnosis of the disease, however, can now be settled with certainty in some cases by the discovery of the spirochæta, and with considerable probability in others by Wassermann's test (see Appendix), and this objection therefore falls to the ground in these cases. It may be laid down as a general rule that mercurial treatment should be begun as soon as the diagnosis can be made.

During the primary stage iron is of great value and may be given as Blaud's pills (five to ten grains three times daily immediately after food) in capsules or cachets. Cachectic subjects should be given a tonic such as half a drachm of Easton's syrup three times a day in a wineglassful of water.

The General Treatment of Secondary Syphilis.—The principal drug employed in the treatment of the secondary stage is *mercury*, and the chief points to be considered are in connection with its administration. Whilst mercury is being taken, the following points should be attended to:

(1) Only plain and nourishing food should be taken, indigestible matters, spices, and condiments being avoided.

(2) Alcohol should be given up, unless the patient is accustomed to take it regularly, when a small amount, of a light claret, hock, or sauterne may be allowed.

(3) Regular exercise should be taken; but violent forms, such as football, hunting, and the like, must be avoided, as otherwise greater quantities of mercury will be required to bring the patient properly under its influence. It has long been recognised that persons taking mercury are prone to catarrhs of a severe type.

(4) The care of the teeth is of the highest importance. If tartar be allowed to accumulate on them, salivation may occur before the patient is fully under the influence of the drug, and there may be considerable difficulty in continuing the mercury on account of the premature tenderness of the gums. The teeth should be brushed frequently during the day, and an astringent mouth-wash containing alum and tincture of myrrh, or ten grains of chlorate of potash to the ounce of water, may be employed if there be any tenderness.

(5) Smoking should be prohibited because the irritation it gives rise to predisposes to and keeps up throat, mouth, and tongue affections.

Modes of Administration of Mercury.—Mercury may be administered by the mouth, by the skin, and by intra-muscular injection. Administration by the mouth has many advantages, and we recommend it for all cases except those in which there is some definite indication for its administration by other means. It is simple, cleanly, and painless, and involves the minimum amount of trouble to both surgeon and patient. There are, however, two groups of patients for whom it is unsuited—namely, those who wish to avoid taking the drug and those who assimilate it from the alimentary canal either too slowly or not at all. Therefore intramuscular injections are largely employed in the public services, partly on account of the simplicity of the procedure, the accuracy of the dosage and the consequent shortening of the course, but chiefly because the patient is certain of receiving and absorbing the desired quantity of mercury. In all cases in which gastro-enteritis follows the administration of the drug by the mouth and in those of very severe and rapid syphilis in cachectic subjects, some more rapid means of bringing the patient under the influence of the drug than that obtained by oral administration should be adopted. The only drawback to administation by the mouth in cases in which it is well borne is that the course is longer, on account of the slower absorption of the drug from the alimentary canal.

Among the various preparations of the drug administered by the *mouth*, the metallic form acts best during the early stages, and is usually given either in the form of blue pill or as a pill of hydrargyrum cum cretâ. In this stage also it is well to combine it with iron, and the following is a good formula :

℞ Pil. hydrargyri.	gr. 1
Ferri sulphatis	gr. $\frac{1}{4}$
Extract. opii	gr. $\frac{1}{8}$

M. Ft. pil. Two pills to be taken thrice daily.

'Hutchinson's formula' consists of hydrarg. c. cret. and Dover's powder in equal quantities made up into four-grain pills, one of which is taken three times a day. The amount of Dover's powder should be varied according to the action of the mercury upon the bowels. The quantity of mercury may be gradually increased, so long as no intestinal irritation is produced, until the mercury begins to manifest its physiological effects, as shown by salivation or soreness of the gums. When this stage is reached, the dose should be reduced, or, if the tenderness of the gums be extreme, the drug may be discontinued entirely for two or three days until the tenderness has passed off, when it may be resumed in smaller doses. It should not be discontinued altogether when the physiological effects manifest themselves ; as a rule the secondary phenomena do not disappear until the physiological action of the mercury is apparent. This method is the one we prefer to use if possible.

The accompanying table, taken from the *Manual of Venereal Diseases*, by the officers of the R.A.M.C., indicates the methods adopted in the army for the treatment of syphilis. Any course is, however, liable to necessary variations, and must not be adhered to too strictly. The table gives, however, an excellent guide to the amount of mercury necessary in an average case.

Treatment by 1 gr. Hg Pills	Months	Pills	Grs. Hg
First Course.			
1 month, taking 6 pills a day	1	180	60
3 days' rest	—	—	—
1 month, taking 4 pills a day	1	120	40
7 days' rest	—	—	—
1 month, taking 3 pills a day	1	90	30
1 month's rest	1	—	—
Second Course.			
3 months, taking 3 pills a day	3	270	90
1 month's rest	1	—	—
Third Course.			
3 months, taking 2 pills a day	3	180	60
Interval of 1 month	1	—	—
Fourth Course.			
3 months, taking 1 pill a day	3	90	30
3 months' rest	3	—	—
Fifth Course.			
3 months, taking 1 pill a day	3	90	30
Total .	21	1,020	340

Thus the course lasts a little more than twenty-one months, during which time the patient takes 340 grains of mercury.

At a later stage of secondary syphilis in weakly subjects other forms of mercury often act better, and give rise to less intestinal irritation than the one just described. The green iodide of mercury, for example, may be given in pill form, in doses of a quarter to half a grain combined with a quarter of a grain of extract of opium, three or four times a day. In the late secondary stage, and especially when the patient is very anæmic and feeble, the French preparation known as 'Gibert's syrup' is often extremely good. Each ounce of this contains one-twelfth of a grain of biniodide of mercury, five grains of iodide of potassium, syrup, and water.

When more rapid mercurialisation is required in a patient who will carry out instructions faithfully, it is best to employ *inunction*, and in the later stages of the secondary period iodide of potassium should be administered internally at the same time. The longer the syphilis has lasted the better is the result obtained by combining iodide of potassium with the mercury. The ointment usually selected for inunction is unguentum hydrargyri, but better results are obtained with a 10 or 20 per cent. oleate of mercury combined with an equal quantity of lanoline; this preparation has the advantage of not soiling the linen as much as the blue ointment generally does.

Inunction is carried out as follows. A portion of the unguentum hydrargyri about the size of a hazel-nut is rubbed well into the skin every night, if possible before a warm fire, and fifteen or twenty minutes should be occupied in doing this. The ointment may be rubbed into any part of the body where the skin is comparatively thin, preferably into the axillæ or the groins, and the same part should not be used on two successive nights, as otherwise considerable irritation of the skin, and possibly a pustular eruption, may be caused. For example, the inunction should be made into one axilla on the first night, into the other the following night, whilst on the third one groin, and on the fourth the other may be chosen; on the fifth night inunction may be employed over the abdomen, and the patient should wear the same under-linen and should not have a bath during these five days. At the end of this period he should take a warm bath, and then commence again, and go on in this way until the gums become tender, which will usually be in about six or ten days. As soon as this happens, the patient should have a warm bath, put on clean linen, stop the inunction, and substitute for it the internal use of mercurials, such as two-grain doses of pil. hydrargyri combined with extract of opium, three or four times daily (see p. 219). Should the condition of the gums get worse under this treatment, the dose of pil. hydrargyri should be reduced; should it improve, the dose may be increased slightly, and continued for two or three weeks after the eruption has disappeared, when it may be reduced to one-half or one-third of the amount; this must be continued for a considerable time (see p. 220).

In the 'Manual of Venereal Diseases' the plan recommended is to use for each inunction ung. hydrarg. gr. xl and adeps lanæ (B.P.) gr. xx. The course of treatment is as follows; the course lasts nearly two years and no less than 3,280 grains of mercury are employed:

Treatment by Inunction	Months	Inunctions	Grs. Hg
First Course.			
42 daily inunctions	1½	42	840
3 months' rest	3	—	—
Second Course.			
Same as first	4½	42	840
Third Course.			
30 daily inunctions	1	30	600
6 months' rest	6	—	—
Fourth Course.			
30 daily inunctions	1	30	600
6 months' rest	6	—	—
Fifth Course.			
20 daily inunctions	⅔	20	400
Total .	23⅔	164	3,280

Another method of introducing mercury into the system through the skin is by *fumigation*, the drug employed being calomel ; it is best performed at bedtime. About thirty grains of calomel are placed in a small metal dish, which is surrounded by another containing a little boiling water, and the whole is placed over a spirit-lamp. This vaporising apparatus is put under the seat of a cane chair, upon which the patient divested of his clothes, sits surrounded by a blanket reaching to the floor, and tucked tightly round the neck so as to prevent the escape of the calomel vapour. It takes about twenty minutes for the calomel to be volatilised, and the patient sits meanwhile in a profuse perspiration, so that the drug is readily absorbed through the skin. After the sitting, the patient is wrapped in a blanket and goes to bed. Two baths a week generally suffice, especially if the patient be weakly, but one may be given every night should it be necessary to get him rapidly under the influence of mercury. This method is useful for obstinate skin affections, but otherwise it is seldom employed ; the smell of the vaporising calomel is very penetrating and offensive.

The administration of mercury by *intra-muscular injections* has been used largely of recent years. The numerous preparations of mercury employed fall into two classes—namely, (*a*) Soluble salts of mercury ; of these we recommend the succinamide of mercury in doses of one-fifth or two-fifths of a grain two or three times a week. (*b*) Insoluble mercurial preparations ; these may contain either metallic mercury or calomel, and are best bought ready prepared, as their manufacture requires minute subdivision of the active ingredient. Perhaps the best formula is Lambkin's, usually spoken of as 'mercurial cream.'

Metallic mercury . . .	gr. j
Creo-camph	grs. ij
Palmitin basis	ad ♏ x

'Creo-camph' is a preparation of creosote and camphoric acid, and is added to prevent the pain which otherwise comes on three or four days after the injection. The above amount constitutes a dose.

The preparations containing metallic mercury are preferable to those containing calomel, as the latter cause severe pain at the site of injection and give rise to more risk of local sepsis.

Intra-muscular injections are of great service when it is required to obtain the physiological effects of mercury very rapidly, or when the administration of mercury by the mouth leads to gastro-intestinal irritation. It possesses the further advantage that the patient is certain of absorbing the given dose of mercury, which does not always happen when it is given in other ways, since the patient may either not take it at all or may not absorb it when taken. The soluble salts allow more accurate dosage, but the injections require to be made frequently and are often painful. The insoluble preparations yield admirable results and need only be injected once a week ; they have the disadvantage, however, that a week's supply of mercury is injected at one sitting and absorption of the drug cannot be checked should any mercurialism manifest itself. The use of such a preparation as a routine in all cases is therefore not to be recommended ; it is better to reserve it for cases in which administration of grey powder by the mouth fails, and in which therefore there can be no abnormal susceptibility to the drug.

The injection should be made with rigid aseptic precautions, the needle, which should be of platino-iridium, should be inserted deeply into the substance of a large muscle, such as the gluteus maximus or deltoid, at right-angles to the surface, care being taken to avoid large nerve-trunks. The needle is best sterilised in olive oil, which does not blunt, it and at the same time acts as a lubricant. Although the material injected contains mercury, it must be carefully sterilised or there may be troublesome suppuration. It is also important to prevent the injection escaping along the needle-track during and after the injection ; if it does, a painful subcutaneous nodule will occur. The injection should not be begun until the needle is well into the muscle, and should then be made slowly so as to separate but not rupture the muscular fibres.

The following is the plan of treatment followed at the Rochester Row Hospital, and gives a good idea of an average course:

Injections of Metallic Mercury	Months	Injections	Grs. Hg
First Course.			
6 injections (each weekly)	1½	6	6
Interval, 2 months	2	—	—
Second Course.			
4 injections (each fortnightly)	2	4	4
Interval, 4 months	4	—	—
Third Course.			
Same as second	6	4	4
Fourth Course.			
4 injections (each fortnightly)	2	4	4
6 months' rest	6	—	—
Fifth Course.			
Same as fourth	2	4	4
Total .	25½	22	22

Each injection consists of ♏x of the cream and contains gr. j of metallic mercury.

It is possible that our present ideas as to the length of time that is required for a course of mercurial treatment may undergo considerable alteration should the Wassermann serum test prove reliable and of general application, as we shall then have a definite means of testing the disappearance of the disease.

The local treatment is usually of considerable benefit in secondary syphilis; the eruptions seem to be favourably affected by the local application of mercury. Eruptions on the face often disappear quickly under the use of emplastrum hydrargyri, the patient meanwhile being treated constitutionally by one of the methods already described. The plaster should be renewed every night; it may be employed usefully also for skin eruptions elsewhere.

Acid nitrate of mercury may also be employed. This preparation, however, is a powerful caustic and must be applied with care, but it is a valuable preparation for mucous patches on the throat and for condylomata, especially when they are ulcerating and spreading; it should be painted on with a glass brush two or three times a week. Condylomata and mucous patches also disappear rapidly when local treatment is combined with the internal administration of mercury. They should be washed night and morning, dried, and dusted over with a powder consisting of one part of calomel and three parts of starch. Lotio nigra makes a valuable gargle in cases of syphilis of the mouth and throat.

The General Treatment of Tertiary Syphilis.—During this stage the lesions will be removed much more rapidly by means of *iodide of potassium* than by mercury. We usually begin with fifteen grains of the iodide of potassium three times a day, and if this does not suffice to influence the lesions rapidly, the dose may be increased up to thirty or forty grains. The iodide should be taken from half an hour to an hour after meals, and it is well to give it with tincture of orange peel or syrup of cinchona in order to avoid griping. Some patients cannot take iodide of potassium; and if it be administered they suffer severely from coryza, pustular eruptions on the skin and pains in the bones. Under these circumstances the sodium or strontium salt may be substituted for that of potassium, but if these cannot be borne, resort must be had to mercurial inunction or intra-muscular injections. It is a curious fact that patients suffer less from the physiological action of iodide of potassium in large than in small doses, and, before giving up the drug entirely, one or two large doses at any rate should be tried.

It must be remembered that iodide of potassium only causes the disappearance of the syphilitic lesions and that it has no permanent curative effect. It is well, therefore, to give the patient a mercurial course at the same time that he is being treated with the iodide of potassium, especially in syphilis of important organs, such as the brain, the liver, etc. After the gums have become affected the mercury may be given up for a short time and then continued in smaller doses just as in secondary syphilis (see p. 219).

The Local Treatment.—The local application of mercury, especially in the form of emplastrum hydrargyri, is often beneficial in the tertiary period. In obstinate cases, and particularly in tertiary bone lesions, much advantage may be gained by excising and scraping away the gummatous material in the same way as tuberculous tissue is treated, but in most instances the lesions rapidly disappear when iodide of potassium and mercury are administered simultaneously.

Sulphur Baths and Spas have a considerable vogue in the treatment of syphilis, and a visit to Aix-la-Chapelle is frequently advised. These waters, however, have no specific effect on syphilis, and the benefit derived from a visit to Aix is due to the careful antisyphilitic treatment carried out there and to the fact that the patient gives himself up entirely to the treatment. The hot baths help the action of the antisyphilitic remedies to a certain extent, and some of the benefit is also due to the complete rest and absence of worry. A nervous overworked business man with an obstinate syphilitic affection may be sent to Aix, Wildbad, or some similar place with advantage, but it would be wrong to put patients of moderate or limited means to the expense of going there. The best time for a visit to Aix-la-Chapelle is May or June, but it is open all the year round.

An important question is, *how long the mercury should be continued*, for there seems good reason to believe that, in the milder cases of syphilis at all events, an actual cure may be brought about by careful treatment; at any rate tertiary symptoms may never supervene. Everyone is agreed that the mercury should be continued in as large doses as possible without producing salivation, at least until the secondary symptoms, for which it is administered, have subsided, and for two or three weeks afterwards. Also, that when fresh symptoms appear, mercury should be again administered as before. It is now, however, a generally accepted view that the treatment with small doses of mercury (about one-third of the dose required to produce the physiological action) should be persisted in after the symptoms have subsided. Should these recur, the full dose is again resorted to. On pp. 220–3 we have given tables showing the periods for which mercury is administered by the officers of the R.A.M.C. and the intervals between the administrations. These may be taken as fairly typical of the general body of opinion as to the duration of the mercurial course, which it will be seen from a reference to these tables is spread over a period of about two years. It must, however, be understood that the administration of mercury must be continuous in the first instance until the physiological action is produced, and that on any subsequent appearance of symptoms the dose must be again raised until the gums become sore.

It is very difficult to say when a patient can consider himself cured, and it is to be hoped that recent work upon the serum diagnosis will be able to afford a definite answer to this question. Fournier considers that a patient may be allowed to marry when he has undergone a full course of treatment (about two years), when he has had no symptoms for at least a year and a half subsequent to this, and when the course of the disease has been mild. If experience bears out the view that the disease is cured when the blood gives a negative Wassermann reaction three months after the end of a mercurial course, a great advance will have been made, and, should this reaction stand the test of time, it will be a most valuable method of checking the results of a mercurial course, and therefore its duration.

HEREDITARY SYPHILIS.

When a child with inherited syphilis is born alive, the lesions are much the same as the secondary and tertiary ones in the acquired form, but they are apt to be more mixed in character, and tertiary lesions may occur quite early.

TREATMENT.—The treatment of hereditary syphilis is essentially the same as that of the acquired form—namely, the use of mercury in the early lesions, and of iodide of potassium, with or without mercury, in the later forms. Mercury is best administered to infants by means of inunction, as by this means irritation of the stomach and interference with the feeding of the child are entirely avoided. One of the most convenient ways is to spread some unguentum hydrargyri (a piece about the size of a small hazel-nut) upon the binder, leaving it to the natural wriggling movements of the child to rub the mercury into the skin. The binder is removed, the skin well washed, and fresh ointment applied daily. Should there be any irritation of the skin, about ten grains of a ten-per-cent. oleate of mercury may be rubbed into the legs and arms instead of using the abdominal inunction. As soon as the symptoms begin to improve, the quantity used should be diminished, but mercurial treatment should be gone on with, either in the form of mild inunctions or by internal administration, at any rate for the first year after birth. If internal administration of mercury be preferred, one-sixth of a grain of hydrarg. cum cret., or one-hundredth of a grain of bichloride of mercury well diluted may be given three or four times a day. The hydrarg. cum cret. may usefully be combined with bicarbonate of soda in the proportion of one grain of the former to five of the latter; one grain of this is given three or four times a day to an infant. The bichloride of mercury may be given in the form of liq. hydrarg. perchlor. flavoured with aq. anethi or aq. chloroformi. At the same time it is of great importance to attend to the proper feeding of the child.

In prescribing iodide of potassium, the dose will vary with the child's age. Sir Lauder Brunton's plan of calculating the dose for different ages is very simple and efficacious. He takes the age for the full adult dose as twenty-five, and reckons the age of the child at its next birthday as an integral part of that number; the full adult age is used as the denominator, and the child's age thus reckoned is used as the numerator.

Thus, the dose for a child in the first year of life would be one-twenty-fifth of the adult dose, that for a child one year old, two-twenty-fifths of the adult dose, and so on. When the syphilis has not appeared, or at any rate has not been treated with mercury, in infancy, it is well to employ mercurial inunction in addition to the iodide of potassium which will be required in the later manifestations of the disease.

'Salvarsan' in its application to this form of the disease has been referred to above by Dr. Emery (see p. 216).

CHAPTER XII.

TUBERCULOSIS.

TUBERCULOSIS is an infective disease, due to the growth of the tubercle bacillus in the tissues. The affection is characterised by the formation of nodules or tubercles tending to run together, break down and caseate, and to destroy the structures in which they are situated.

SEATS.—The most frequent seat of tuberculosis is, perhaps, the lymphatic glands, more particularly those of the cervical, bronchial, and mesenteric regions. Another common seat of the affection is the periosteum, and the cancellous tissue at the ends of bones. Tuberculous lesions are frequently met with in the synovial and serous membranes; they may also occur in various internal organs, such as the lungs, the kidneys, the prostate, etc. In fact, a tuberculous lesion may occur wherever there is connective tissue and a suitable spot for the growth of the bacillus after it has gained access to the body.

ACCESSORY FACTORS.—Although the tubercle bacillus is the essential cause of tuberculosis, a number of accessory factors are concerned in the production of the disease; without their concurrence the affection often would not occur. These accessory causes may be local or general.

Local.—Among local factors *injury* plays an important part as a predisposing and, sometimes, as an exciting cause of the tuberculous lesions; this is most frequently the case in tuberculosis of bones and joints. It is important to note that the injury must be a mild one; a severe one, such as a fracture, does not usually lead to the deposit of tubercle in the damaged part, probably because the processes of repair are then so active that the bacillus cannot cope with them. A slight injury, on the other hand, particularly one in the nature of a sprain, weakens the tissues without leading to any marked cell-exudation, and the bacilli then seem able to obtain a good footing in them. *Exposure to cold* probably also acts in this way, and, when the bacilli are already present in the body, it leads to their deposit in the part subjected to the action of the cold. Indeed, anything which lowers the vitality and resistance of the tissues predisposes them to the attack of the tubercle bacillus.

Sepsis is also important, not so much as an inducing cause as one which increases the activity of the disease, or at any rate interferes with its spontaneous cure. *Chronic inflammation* of a tissue seems to weaken it and to enable the bacilli to obtain a foothold and to spread more rapidly than in healthy parts, and anything which keeps up a state of chronic inflammation may favour the development of tubercle in persons in whose bodies the bacilli are present.

There are also *certain conditions connected with the bacilli* themselves which are of great importance, the principal being the number of the organisms that gain access to the part. When the bacilli are few in number the risk of infection is not great, and if it does occur, the disease is generally more chronic than when they are numerous. The bacilli also vary in virulence under different conditions; and, lastly, the result depends a good deal upon whether they are free or are attached to coarser particles. When bacilli are isolated and are present only in small numbers they sometimes pass through the mucous membranes and become caught in the neighbouring lymphatic glands without giving rise to any primary disease at the seat of entrance; this is more especially the case in the intestinal tract and the lungs. When, however, they are attached to coarser particles, as, for example, when the source from which the infection is derived is cheesy material which is not broken up very fine, then there is a local tuberculosis at the point of entrance, from which glandular infection may result.

General.—The question of *heredity* is one of the first for consideration, and it is held by many that tuberculosis is an hereditary disease. As a matter of fact, however, there is no evidence of true heredity; what seems to be inherited is only the tendency of the tissues to form a good nidus for the growth of the tubercle bacillus. This tendency may also be induced by such conditions as bad hygiene, confinement in close rooms, foul air, etc.; according to others, the same result is produced by the ingestion of foods rich in potash and deficient in sodium, such as an excessive amount of vegetables, especially potatoes.

Age and sex appear to exercise an important influence on the development of tuberculosis, although we cannot exactly say in what way the influence is exerted. Surgical tuberculous diseases are most frequent in children before the *age* of ten, but they also occur up to old age; and it is important to note that, the older the patient is, the less is the likelihood of a spontaneous cure. *Sex* has also a considerable influence in so far that females do not seem to be so predisposed to certain forms of tuberculosis as are males. This applies more particularly to the affections of bones and joints; and although this may be explained to some extent by the greater exposure of the male to injury, this consideration does not entirely meet the facts. *Climatic conditions* are important accessory factors. When individuals are exposed to cold and wet, and when, moreover, they congregate in small over-heated rooms, the disease is very apt to occur, especially if one of the community has tuberculosis and thus forms a focus of infection for the rest.

PATHOLOGY.—When introduced into the tissues, the bacillus leads to the formation of a collection of cells, termed a *tubercle*. This is a collection of densely packed lymphocytes surrounding a central mass of cells termed epithelioid cells, which are much larger than the ordinary lymphocyte, and are probably derived from pre-existing connective-tissue cells, from the lymphatic endothelium, or even sometimes from the endothelium of the blood-vessels. Among these epithelioid cells one or more giant cells are formed, probably by the imperfect division of epithelioid cells, the nuclei dividing and separating, but the protoplasm remaining undivided. The tubercles increase in number until a large mass is formed ; *caseation* then commences in the older tubercles, the cells gradually die, and a cheesy material is formed in the centre, or at any rate in the older part of the mass ; this may become encapsuled and remain quiescent, or it may give rise to a *chronic abscess*. There is generally a considerable area around the tubercles which is not yet infected with the bacillus, but which is in a state of chronic inflammation ; this chronic inflammation is of great importance in favouring the spread of the tubercle bacillus, which invades any structure thus affected more readily than one that is quite healthy.

Retrogressive Changes.—The resistance of the living tissues to the growth of the organism is considerable, so that when the causes which facilitate the progress of the disease are removed, the bacillus may be destroyed or gradually cease to grow. Retrogressive changes then take place, consisting essentially in the conversion of the tubercle into *fibrous tissue* and the ultimate disappearance of the tuberculous material. When the tuberculous tissue has undergone caseation, however, and recovery takes place, portions of the cheesy material are absorbed, whilst others are left behind and become *encapsuled* or calcified and quiescent for the time being. Unfortunately the bacilli or their spores retain their vitality in these masses for an indefinite period ; as long as the capsule around the caseous material is unbroken, and the latter is protected from the action of the cells and juices of the tissues, the bacilli seem to lie dormant, but any slight injury or some constitutional cause may break up the encapsuled mass and lead to fresh growth of the organism and fresh infection of the part. It is very important to remember that, when the conditions are favourable, the body has a very strong tendency to check the growth of the bacillus or even to overcome it altogether.

Various causes prevent the living tissues from destroying the tubercle, and these influences must be borne in mind so that, if present, they may be neutralised or removed. The majority of them have already been mentioned ; they are the conditions of the tissues which facilitate the growth of the bacilli, such as those produced by heredity or induced by food ; attention to diet is therefore an important point in treatment. Injuries not only predispose the tissues to the deposit of tubercles in the damaged part, but are also likely to increase the virulence of the disease when present. Cold or sepsis acts similarly, while the influence of climate and hygienic conditions is great. The relation of tuberculosis to other diseases is also of interest, for the occurrence of the latter in tuberculous patients is apt to light up the disease or to encourage its spread. This is especially the case with regard to influenza, measles, and chicken-pox, and therefore exposure to these diseases should be avoided as far as possible.

TREATMENT.—Only the **General Treatment** of tuberculosis will be dealt with here ; the local treatment must be considered in connection with the parts affected, and is described in speaking of the various structures in which it may arise. The general treatment of tuberculous disease has two chief aims—viz. to place the body in a better condition to resist the progress of the disease, and to act directly upon the tuberculous process. The methods of treatment directed to the latter end consist essentially of various forms of operations, and the use of various substances supposed to favour the destruction of the tubercle bacillus—for example, Koch's tuberculin or one of its modifications, iodoform, benzoate of soda, and many others. The dosage and methods of administration of tuberculin are dealt with by Dr. Emery (see Appendix).

There are various methods of general treatment designed to increase the resisting power of the tissues, or to remove the causes favouring the growth of the bacillus, which may be indicated here. An essential point is to put the patient under the best possible **hygienic conditions.** A tuberculous subject must be kept from exposure to cold and wet, which may not only induce tuberculosis in some part of the body not yet affected, but may also exaggerate a lesion already existing. He must have the maximum amount of fresh air and sunshine possible, and therefore it is important that he should live a healthy outdoor life. There is, however, no special climate suitable for all tuberculous cases. Some do better in a cold and bracing climate, others in a warm one, provided it be not relaxing. Hence all patients should not be sent to the same place, or to the same sort of climate ; it is necessary to ascertain which suits the individual best. The only *sine quâ non* is that it should be possible to be out of doors at the place selected practically all day without danger of taking cold. The patient should in fact lead the 'open-air life' that is so much in favour in the sanatorium treatment of tuberculous disease of the lung. When the lower extremities are unaffected, sufficient exercise must be taken, but it must be of such a character that the patient runs no risk of injury, for a local deposit of tubercle is likely to occur at any spot injured. The only point of importance with regard to **drugs** is that only those should be ordered which will increase the nutrition of the body. Of these the best seems to be *cod liver oil*, which may be given pure or as one of the many emulsions upon the market. As much of the drug should be given as is possible without disordering the digestion. It is well to begin with teaspoonful doses three or four times a day, and to increase it until the patient cannot bear any more ; the oil should be given, however well-nourished or healthy the patient may appear. As a rule, children take the emulsions well. When pure cod liver oil is used it is probably best to float it on milk. Cod liver oil may be administered to children who resent taking the oil as ordinarily prescribed, by replacing the oil in which sardines are preserved by a tasteless variety of cod liver oil and serving it on the plate with the fish. The tin is filled up from time to time with the oil, and children who are fond of sardines will often take large quantities of the oil in this manner without demur. The drug is apt to disagree during warm weather, and it should be intermitted during the summer ; useful substitutes are large quantities of cream (given in tea, with junket, or with stewed fruit), fat bacon or ham for breakfast, and salads dressed with an abundance of olive oil.

A very popular drug in tuberculosis is *syrup of the iodide of iron*, in doses of fifteen to twenty-five minims three times a day, mixed with water or milk, but it is questionable whether it does any good. Among other drugs, iron is of value, either as tincture of perchloride of iron in ten- or fifteen-minim doses, or as Blaud's preparation in doses of from three to ten grains, according to the age of the patient. Tincture of *nux vomica* is useful when the appetite is bad ; in fact, any drug that will increase the general nutrition of the patient may be administered with advantage. *Guaiacol* in doses of one to five minims is much in vogue at the present time, and seems to be of some service.

When exercise cannot be obtained, as may happen when the situation of the disease demands absolute rest in bed, benefit may be obtained by general *massage*. This, for example, may be usefully applied to the extremities when the spine is the seat of the disease, or to the upper extremities or the trunk when the lower limbs are affected, and in this way a substitute for exercise can be obtained. By these means both the appetite and the general nutrition can be well sustained. Efforts must also be made to diminish the inflammation about the affected area, and the tendency to cure is greatly strengthened if these be successful. The first essential in this part of the treatment is absolute rest, for, apart from the presence of the tuberculous disease, movement promotes the inflammatory condition. Sometimes, as in joint-disease (see Vol. III.), the pressure of the inflamed articular surfaces against each other due to the tonic contraction of the muscles around the diseased joint keeps up the inflammation, and therefore rest must be combined with extension, so as to relax the muscles.

Various other methods may be employed to remove the chronic inflammation; the actual cautery (see p. 20) is of value in many cases of deep-seated bone and joint disease; pressure is also of use and may be employed in combination with counter-irritation, as by Scott's dressing (see p. 23), or alone, by wrapping the joint in a large mass of wool and then applying a firm bandage over it. The various measures for combating chronic inflammation are fully described in Chapter I.

CHRONIC ABSCESS.

A chronic abscess is usually tuberculous in nature; in it an abscess forms without any of the cardinal symptoms of inflammation except the swelling, pain is absent or very slight, there is not necessarily any pyrexia, though the affected area may feel warmer than the surrounding parts, and there is no redness of the skin over the seat of the disease, unless the skin itself be involved. The swelling is caused by the presence of fluid, and differs entirely from the brawny swelling that is met with in acute abscesses.

A chronic subcutaneous abscess begins as a small tuberculous nodule which gradually increases in size, undergoes caseation, and softens in the centre. When this occurs, the inflammation around becomes a little more active, and there is an effusion of fluid, along with a considerable number of white blood corpuscles, mainly lymphocytes, into the cheesy material; the result being an investing layer of tuberculous tissue containing fluid mixed with broken-down cheesy material, disintegrated tissue, and lymphocytes. The essential part of a chronic abscess is its wall, and to this any curative treatment must be particularly directed. This wall consists of two distinct strata—an inner of soft granulation-tissue which can be readily scraped away with a sharp spoon, and an outer fibrous layer which can only be removed with a knife or scissors. There is no sharp line of demarcation between these two layers, and the outer one often merges into the surrounding tissue. The mere evacuation of the contents of a chronic abscess will not necessarily lead to a subsidence of the disease, as it does in an acute one. The tubercle bacilli and the tubercles themselves are present in the abscess wall, and all that is evacuated when the abscess is incised is broken-down caseous material, along with the fluid and leucocytes that have passed into it as the result of the inflammation around. Even if the abscess be curetted, the disease may not be removed entirely, as there are bacilli in the dense fibrous layer of the wall which remains behind.

TREATMENT.—The treatment must be directed to the wall of the abscess, and this is done in various ways.

Excision.—When the abscess is small and subcutaneous, the simplest plan is to excise it with its contents intact, as if it were a sebaceous cyst. Similarly, when the abscess is connected with a gland, and even when it has perforated the gland capsule and spread through the fascia to the subcutaneous tissue, the only satisfactory treatment is to dissect out the wall of the abscess and the affected gland along with it. To dissect away completely and cleanly the abscess wall and the focus from which it originates may be regarded as the ideal treatment of a chronic abscess. If the abscess has thinned and infected the skin, the affected portion of the skin should be removed also, as any attempt to save it will leave tuberculous material behind, which may act as a focus for re-infection of the wound, so that healing may be delayed; if left, the thinned skin will die and an ugly scar will result. Hence all adherent skin should be excised, and the edges of the wound brought together after undermining the skin around; the wound is then stitched up completely and treated as an aseptic incised wound (see p. 133). Should the abscess burst during the dissection, and pus escape, the wound should be thoroughly douched out; tuberculous infection of the wound rarely occurs under these circumstances. When the abscess is connected with a gland, it is not sufficient to remove only the gland that has led to the abscess; any others in the neighbourhood that are enlarged should also be taken away.

Partial Removal of the Abscess Wall.—In large deep-seated chronic abscesses it is impossible to remove the wall completely. Here the surgeon has the choice of two procedures. If the abscess be situated so deeply that it cannot be dissected away, and if no important structures intervene between its wall and the surface, the former should be laid open freely (unless it be important to avoid causing a scar), so that the whole interior of the abscess cavity is exposed to view; as much of the wall as possible should then be dissected out and clipped away with scissors. Any portions that cannot be treated in this manner must be thoroughly scraped. The best instrument to use for this purpose is Barker's flushing spoon (see Fig. 52), by means of which a stream of fluid is kept constantly flowing over the parts, so that the material loosened by the spoon is carried away at once and does not lodge in the recesses of the wound. The fluid used for this irrigation should be 1 in 4000 perchloride of mercury. When the abscess cavity has been thoroughly scraped and cleansed from all flakes of cheesy material and pus, two or three drachms of an iodoform and glycerine emulsion[1] should be poured into the wound according to the size of the abscess; the object is to employ enough of the emulsion to come into contact with the whole of the scraped abscess wall. The wound is then stitched up and, wherever it is possible, pressure is applied so as to bring the deeper parts together and to avoid leaving a cavity. In many cases the wound heals by first intention when treated in this way and there is no further trouble.

[1] The emulsion is made by adding 10 parts of iodoform to 90 parts of glycerine which contains $\frac{1}{2000}$th part of corrosive sublimate.

Incision and Scraping.—Another method must be employed when the parts in front of the abscess wall prevent it from being laid freely open, as, for example, in the case of a psoas abscess, or when it is essential to avoid a large scar. In such cases it is usual to make a small opening sufficient to admit the finger, or the finger and a sharp spoon, and then to wash out the contents of the abscess with sterilised salt solution by means of Barker's flushing spoon. The opening in the skin must be large enough to allow of the free escape of the fluid by the side of the spoon, which is pushed into all the recesses of the abscess, and is used for scraping the wall when all the fluid part has been evacuated. The whole of the wall is scraped gently but systematically. Special care should be taken to use the instrument very gently in any direction in which important fragile structures such as the peritoneum or large veins are likely to be encountered. After the spoon is withdrawn, the cavity is wiped out with fragments of rough sponge. Pieces as large as can be forced into the cavity are used ; they not only soak up any of the flushing solution which remains, but their rough surface scrapes off any tags of cheesy material which still adhere, and so completes the cleansing of the cavity. About half an ounce of the iodoform and glycerine emulsion is then injected, and the skin wound is closed by sutures, which also include the opening through the fascia. The use of the iodoform emulsion is not essential, as some cases seem to do as well without it ; on the whole, however, better results seem to follow when it is employed.

The skin incision usually heals by first intention, and in a certain number of cases no re-accumulation takes place. Sometimes, however, it is found that deep-seated fluctuation is present after a few weeks ; and this is not remarkable, since the actual cause of the abscess—namely, the bone disease—is but seldom accessible to radical treatment (*i.e.* the removal of the primary focus). When accumulation takes place, and is found to be increasing, a fresh incision should be made into the sac and the fluid again evacuated. The sac will be much smaller than it was originally, and the fluid of a brown serous character containing iodine and iodoform. The sac wall should again be scraped, flushed out, and injected with iodoform and glycerine as at the first operation. In many cases two operations suffice to cure even a large abscess of this kind. In some, however, three or even more are requisite, but in the majority of cases the patient can be got well in this way much more quickly and much more certainly than by the old plan of draining the abscess. Sometimes the wound gives way after healing by first intention and a small sinus forms in the scar. Should this happen, the wound must be opened up, scraped out thoroughly and stitched up as before, after the sinus has been dissected out. Unless this be done, the sinus may take as long to heal as it did when the old plan of simple drainage was employed. Even should a sinus form again, the same procedure should be repeated.

The old plan of aspiration of an abscess, which was in common use before Lister commenced his work, has been revived of late years, and though not so efficient as the method just described, possesses the advantage that there is less risk of sepsis in the hands of those unskilled in aseptic treatment. The skin is purified in the usual way and a sterilised aspirating needle is thrust through it at some distance from the abscess and pushed on until it enters its cavity, when the fluid is gradually withdrawn. The needle should not be thrust through the most dependent part of the abscess, and it is important to prevent any of the contents finding their way into the needle-track, lest a sinus should form. With this object in view, the piston of the aspirating syringe should be steadily withdrawn as the needle is pulled out.

Only the fluid part of the contents of the abscess cavity can be withdrawn in this way ; cheesy particles will not pass through the canula, and in order to overcome this difficulty, it is the practice to inject some 'modifying fluid' with the object of rendering the contents thinner and able to flow through the canula at the next aspiration. For this purpose it is usual to inject from 15–60 minims of a saturated solution of iodoform in ether, according to the size of the abscess, after as much of the fluid contents of the abscess as possible has been withdrawn. When this fluid is injected, the heat of the body volatilises the ether, which escapes through the canula, leaving the iodoform diffused over the abscess. When all the ether has escaped, the needle is withdrawn. For full particulars of this method the reader should consult an interesting paper by Calvé and Gauvain (*Lancet*, March 5, 1910). The chief objection to the operation is that it needs to be repeated on several occasions ; its chief advantage is that it does not need a general anæsthetic.

It is needless to say that these operations must be performed strictly antiseptically ; the entrance of septic organisms or even of saprophytes would seriously endanger the patient's life. Before the introduction of antiseptic treatment few cases of psoas abscess recovered.

The **general health** must be attended to and good hygienic conditions, absolute rest to the part, and the administration of cod liver oil and nourishing diet, must be insisted upon. The administration of tuberculin (see Appendix) is also advisable in many cases. The subject of chronic abscess has to be considered again in connection with tuberculous disease in the various organs, but what has been said will suffice to indicate the general principles of the treatment.

DIVISION IV.

TUMOURS.

CHAPTER XIII.

TUMOURS.

DEFINITION.—Tumours may be defined as localised swellings which, though part of the body, grow continuously and independently of it and without relation to any known cause. A tumour continues to grow, and, as a rule, nothing short of its complete removal will permanently arrest its development. It must be distinguished from hyperplasia on the one hand and from an inflammatory swelling on the other. Hyperplasia is a simple increase in the size of an organ, which, however, retains its natural form and structure and, as far as we know, its function; inflammatory swellings do not possess any inherent power of growth and only continue to increase as long as the causes which give rise to them continue to act.

Tumours may grow inside an investing capsule or they may be devoid of one, and they then grow by invading the surrounding tissues, destroying them and taking their place; in some cases minute portions of the tumour may be carried by the lymphatics or blood-vessels to distant parts and there give rise to secondary growths.

It is unnecessary to go fully into the question of tumours here, because their treatment must be discussed in detail in connection with the various organs and tissues in which they occur. We shall, however, make a few general remarks concerning them in order to save repetition in the future.

CLINICAL CLASSIFICATION.—Tumours may be classified both from a clinical and a histological point of view. Clinically they are divided into simple and malignant tumours.

Simple Tumours.—By a simple tumour, such as an ordinary lipoma, is meant one which is of slow growth ; which does not produce any constitutional disturbance, such as wasting or cachexia, unless it be situated in some vital organ ; which does not cause pain, unless its size or its situation causes it to press upon nerves ; which has no inherent tendency to ulcerate and fungate by destroying the skin over it, and only does so when the skin gives way as a result of the pressure to which the bulk of the tumour subjects it ; and which does not cause secondary growths elsewhere. A simple tumour is generally surrounded by a capsule and does not infiltrate the tissues around, nor does it recur after being removed completely. It is freely movable and readily separable from the surrounding parts, unless accidental attacks of inflammation have occurred about it ; in structure it resembles more or less closely some of the normal tissues of the body.

Malignant Tumours.—A malignant tumour, such as an epithelioma, usually grows rapidly and after a time produces severe constitutional effects, known as cachexia, the patient wasting, becoming pale and sallow, and evidently suffering from chronic poisoning. The growth is often painful, apart from its situation, because it involves nerves, and undergoes softening ; when it is near the skin it may destroy it, and lead to ulceration and fungation. It is not encapsuled, any apparent capsule being really a false one and not marking the true limits of the disease. As a rule it grows by infiltrating and destroying the surrounding parts and replacing them by tumour substance, and also by producing secondary tumours elsewhere. Malignant tumours are usually hard and not freely movable, on account of their infiltrating nature. They frequently recur after removal. In structure they differ widely from normal tissues.

HISTOLOGICAL CLASSIFICATION. — Histologically tumours are divided into those composed of cellular elements and those in which the structure is more complex ; the former are again subdivided, according to the type of cell that forms their chief constituent, into tumours composed of epithelial tissues, and into tumours of the connective-tissue type. The tumours belonging to this latter class are not composed of cells alone, but contain in addition blood-vessels, connective tissue, and lymphatic vessels. So far as we know, however, they are not provided with nervous elements.

TUMOURS OF THE CELLULAR TYPE.

EPITHELIAL TUMOURS.

Epithelial tumours are due to the growth of epithelium, which may be regular or irregular, and, if on a free surface, may remain heaped up in masses, or may penetrate into and infiltrate the tissues beneath. The irregular infiltrating form of epithelial growth leads to the formation of the group of malignant tumours, known as carcinomata; the regular non-infiltrating form gives rise to the benign growths.

BENIGN VARIETIES.—Of this class we have two forms—namely, those in which the epithelium grows on a free surface,—the papillomata,—and those in which the growth is in the substance of the tissues,—the adenomata. The papillomata do not strictly belong to the tumour group, because many of them are of irritative origin and sometimes disappear spontaneously; nevertheless it is most convenient to refer to them here.

Papillomata.—This group includes warts, or papillomata proper, corns and horns. **Warts** on the skin are usually hard and sessile, while on the mucous membrane they are soft and pedunculated. The papillæ of which they are composed may be single or branched; it is the branched form that gives rise to the pedunculated growths of which the typical examples are seen on the prepuce.

Treatment.—A simple and effectual method of treating ordinary hard warts on the skin is to pare away the dense epithelium on the surface until the vascular tops of the papillæ are exposed, and then to apply some caustic so as to destroy their bases; the one which answers best and leaves the least scar is salicylic acid. A useful application is a mixture of 100 grains of salicylic acid in an ounce of flexile collodion, which is painted over the wart after it has been shaved down so as to expose the papillæ. Twelve hours later, as much of the collodion as will come off readily is picked away and a fresh layer applied. This is repeated night and morning, and the wart will generally be found to have withered away in the course of a week or ten days; should the action not be sufficiently rapid, the wart should be shaved afresh from time to time.

This method may be sometimes employed for gonorrhœal warts covering the prepuce, when a large raw area would be left if they were clipped off with scissors. In this case it is not necessary to shave the wart before applying the caustic. The prepuce should be retracted, and the wart carefully dried and then painted with the salicylic collodion; this must be allowed to dry before the prepuce is pulled forwards, as otherwise a sore may be produced on the glans by contact with the acid. It is well to introduce a piece of dry boric lint between the glans and the prepuce; this absorbs moisture and prevents contact between the salicylic acid and the mucous membrane of the glans.

A more rapid method of removing warts is the following. Apply undiluted carbolic acid to the wart after the skin around has been carefully greased in order to prevent the acid from running over the normal skin. The carbolic acid is allowed to soak well into the substance of the wart between the constituent papillæ. Then place a small drop of pure nitric acid in the centre of the wart; this produces a brisk effervescence accompanied by destruction of the whole warty tissue. Although the chemical action seems to be extremely violent the method is not particularly painful, the carbolic acid acting to a certain extent as a local anæsthetic. The CO_2 freezing method (see p. 262) recommended for nævi is also of great value. In treating crops of warts it very often happens that when one or two of the largest are cured the rest disappear spontaneously.

Should these methods prove ineffectual, the wart must be removed by the knife. When papillomata are sessile and are situated on the skin, it is not sufficient to clip them off, as they will certainly grow again; it is necessary to excise their bases.

When the papillomata are pedunculated, and the pedicle is narrow, it is best to clip them off with scissors, and to paint the cut surface for a few days in succession with salicylic collodion (see p. 239). The papillomata of the bladder or rectum must be removed by special operations, which are described in their appropriate places.

Horns.—In these cases the epithelium remains heaped up in masses over the surface of the papillæ, and becomes hard and stuck together by some glutinous material. On breaking off the horn, a broad papillomatous base is left which must be dissected away; unless this be done, the horn will grow afresh.

Corns.—A corn is due essentially to intermittent pressure, and as a rule removal of the pressure will lead first to the peeling off of the hard core of the corn, and subsequently to its complete disappearance. Salicylic collodion (*vide supra*) applied after paring the corn, will facilitate its disappearance; a corn, however, needs more frequent paring than a wart. A more certain effect may be obtained by shaving down the epithelium, and applying a thick bunion plaster so that its centre is over the base of the corn. The hole in the centre of the plaster is then filled up with pure salicylic acid and a piece of ordinary plaster is put on over the bunion plaster to keep the salicylic acid in place. The acid thus acts directly upon the base of the corn and is very effectual. The application should be renewed daily as long as may be necessary, any epidermis that can be picked away easily being removed before each fresh application.

Adenomata.—These tumours occur in connection with glands, and in structure are similar to that of the gland in which they develop. It is uncertain whether they originate in a hyperplasia of the epithelium or of the connective tissue, but as a rule so much fibrous tissue is present that the term fibro-adenoma is more appropriate; if the tissue be very embryonic the term myxo-adenoma is used. The adenomata are usually encapsuled, and, when embedded in the substance of the organ, can generally be shelled out of their capsule without any tendency to recurrence.

Treatment.—The treatment is to shell them out of their capsule. In certain positions—*e.g.* in the rectum or œsophagus—adenomata become polypoid, and are dragged downwards by their weight, pushing the mucous membrane before them. In these cases the polypoid growth is cut off after ligature of the pedicle to arrest the bleeding.

MALIGNANT FORMS.—The second great group of epithelial growths is formed by the carcinomata, in which the epithelium grows in an irregular manner ; the cells are larger than the ordinary epithelial ones from which they originate, and the growths infiltrate the tissues and are not encapsuled.

Carcinomata.—The carcinomata differ in malignancy and rapidity of growth according to their situation, to the character of the epithelium in connection with which they grow, and to other circumstances with which we are not well acquainted. The carcinomata which spring from the surface epithelium are generally spoken of as **epitheliomata**, and this class includes *squamous epithelioma*, and *rodent ulcer*, growing from the skin, and the *cylindrical epitheliomata*, springing from the intestinal canal, etc. Those which originate from glandular epithelium are termed the carcinomata proper.

The **carcinomata proper** also form several groups. There is a very soft kind formerly called *encephaloid* cancer, in which the cells are numerous and the fibrous tissue small in amount. They usually grow rapidly and may be very malignant. In marked contrast to these is the *atrophic scirrhus*, in which the cells atrophy quickly, and the growth contains a large amount of fibrous tissue with only few alveoli and cellular elements. These tumours grow extremely slowly and never attain any great size. Intermediate between these two extremes are all gradations.

Mode of Spread.—The essential growing element in the carcinomata is the epithelial cell, and the character of the growth depends upon the mode in which these cells spread. The epithelial cells are usually found enclosed in tubular spaces termed alveoli, which are probably dilated and much altered lymph spaces ; at any rate they communicate freely with the lymphatics. The cells are evidently derived from the normal epithelium of the part in which the disease primarily begins, but they soon multiply independently and show active processes of growth. They rapidly push their way through the limiting membrane of the normal epithelium into the tissues around, and there spread in the lymph spaces and channels ; at the same time it would appear that they attack the walls of the smaller veins, and spread into their interior at an early period, although metastatic deposits, due to infection through the blood-vessels, seldom show themselves clinically until late in the course of the disease.

After spreading into the lymphatic vessels, the cells become detached and carried with the lymph stream, and either become arrested in the vessels when these are small and the cells are large or massed together in groups ; or they are carried on to and caught by the nearest lymphatic glands, where they give rise to secondary tumours. From the nearest lymphatic glands they spread to others in the neighbourhood, and thus fresh groups of glands are affected. Ultimately they get into the blood-vessels, either indirectly through the thoracic duct, or directly by penetrating the walls of the veins. They are thus finally deposited in various organs in distant parts of the body. Hence, in carcinomatous tumours, we have a primary tumour, a secondary glandular infection, and internal or metastatic deposits.

Furthermore, certain special **degenerations** occur in some forms, such as colloid degeneration in carcinoma of the stomach and intestine, and a form of degeneration accompanied by the deposit of pigment which is generally spoken of as melanotic cancer.

Treatment.—If carcinomatous disease is to be rooted out, its mode of spread by means of the lymphatic vessels must be borne in mind, and as this occurs at an early stage, and as the cells are microscopic, a very wide area must be removed by the knife. The organ from which the original growth springs should, if practicable, be excised, because its lymphatic vessels generally communicate freely with each other and there are probably secondary deposits in various parts of it already. In addition, the nearest chain of lymphatic glands must also be removed, even though the glands may not be noticeably enlarged.

It is sometimes difficult to decide whether the lymphatic tract intervening between the primary growth and the glands should also be removed. That this should be done in certain cases—as for example, in breast cancer—is evident from microscopical researches, which have shown that the lymphatic vessels passing from the breast to the axillary glands are themselves affected in the great majority of advanced cases. On the other hand, there are certain forms of carcinoma, especially of the squamous epithelial type, in which the intervening lymphatics do not seem to be readily infected. In epithelioma of the lip, for instance, a secondary tumour rarely arises in the course of the lymphatic vessels, although the glands of the neck may be enlarged. In epithelioma of the extremities also, the lymphatic vessels are not usually affected, although the glands become involved comparatively early. Hence, in these cases, it suffices in the first instance to remove the primary growth and the nearest lymphatic glands, and then to watch whether recurrence takes place in the intervening tissues. In breast cancer, on the other hand, it is wiser to take away not only the breast and the axillary glands, but all the intervening fat and fascia with the lymphatic vessels running in them, if we wish to make sure of avoiding recurrence ; this also applies to cancer in most other situations. Details of the various operations are given in connection with the affections of the individual parts and organs.

Radium is useful, when sufficient is available, in some superficial forms of epithelioma that cannot be removed sufficiently widely. It is chiefly used at the present time in connection with rodent ulcer (see p. 249), for which it is very effectual. For true epithelioma it should not be used as a substitute for excision.

Endotheliomata.—This term includes a large group of tumours which are very diverse clinically, some being highly malignant, while others are to all intents and purposes innocent. They grow from the endothelial lining of blood-vessels, from the lining of the perivascular lymphatic spaces, from the endothelium of the tissue lymph-spaces and lymph-vessels, and from the surface of the serous membranes. Clinically they do not present any special characteristics and in practice can be treated in accordance with the clinical signs; that is to say, those tumours which exhibit the characteristics of malignant disease should be treated as malignant, while those which resemble simple innocent tumours should be treated as innocent.

TUMOURS OF THE CONNECTIVE-TISSUE TYPE.

These are of two kinds—viz. those in which the connective tissue is embryonic in character—*e.g.* sarcomata and myxomata; and those in which the connective tissue is more fully formed—*e.g.* fibromata and lipomata.

MALIGNANT FORMS.—The **Sarcomata** form fleshy tumours composed of embryonic connective tissue. They are rounded and nodular and generally have a spurious capsule, which is composed of sarcomatous tissue and must be looked upon as an integral part of the growth itself. They vary in malignancy, but all possess to some extent a decidedly malignant character. They may occur wherever there is connective tissue, and are most frequently met with in the bones, fasciæ, muscles, skin, breast, testicle, uterus, kidney, parotid, and nerves. The cells vary in character, and the sarcomata are therefore subdivided into a number of varieties according to the general character of the cells composing them. In addition to the cells there is a certain amount of intercellular substance which varies in degree and stage of organisation with the class to which the tumour belongs. The consistence and appearance of the tumour depends to a great extent on the amount of intercellular substance present.

These growths are usually very vascular and are especially rich in capillaries and veins. They may undergo various degenerations; they compress and destroy neighbouring parts, surround vessels and nerves, and may lead to ulceration of the skin, either after involving it or, more commonly, by causing sloughing from pressure and then fungating through the opening thus formed. They give rise to secondary tumours around the primary one, or spread through the medium of the circulation. The secondary internal tumours occur most commonly in the lungs and the liver. In the softer and more embryonic varieties, the lymphatic glands may become affected; though this is not nearly so common as in the carcinomata.

Of the varieties of the sarcomata may be mentioned the **round-celled sarcoma,** which is usually soft and white like the milt of fish, and very malignant; the **spindle-celled sarcoma,** which is generally firmer, of a greyish or yellowish-white appearance, and not so malignant as the round-celled variety; it occurs most frequently in connection with the fasciæ; the **myeloid sarcoma,** in which there are myeloid or giant cells in addition to polymorphous or spindle cells. This form is soft, of a chocolate colour, and generally contains numerous cysts, due to degeneration occurring in connection with the myeloid cells. It occurs in the interior of the articular ends of bones, and in the lower jaw. It is the least malignant of the sarcomata and seldom gives rise to secondary tumours; it may often be removed without amputation and without recurrence. Some authors separate these myeloid tumours from the sarcomata and place them in a group by themselves under the name of myelomata.

The **melanotic sarcomata** contain polymorphous or spindle-shaped cells in which early pigmentary degeneration occurs. They originate in parts where there is normally pigment, such as the skin or the choroid. They are the most malignant of the sarcomata, affecting the glands early, and recurring with great rapidity. **Alveolar sarcoma** is comparatively rare. In it the cells are arranged in groups separated by connective tissue or spindle cells, giving rise to an alveolar arrangement. **Osteo-sarcoma** takes origin from the periosteum and is extremely malignant; a certain amount of ossification takes place in it, so that spicules of osseous tissue are found projecting from its surface when the affected bone is macerated. The secondary deposits to which this form gives rise are apt to undergo similar ossification. A somewhat analogous condition is seen in the variety known as **chondro-sarcoma,** which is met with sometimes in soft tissues, such as the testicle or the parotid, and in which chondrification occurs; it is a very malignant form.

Treatment.—All sarcomata should be excised freely. Any capsule that the tumour possesses must be taken away; in fact, it is well to make sure that a considerable area of healthy tissue beyond the capsule is included in the removal. When the sarcoma arises in connection with bone, amputation is generally necessary, and moreover, in cases of periosteal sarcoma it is advisable to disarticulate through the joint above the bone affected, because it will be found on microscopical examination that the growth generally spreads in the periosteum to a considerable distance beyond the naked-eye limits of the tumour, and recurrence is likely to take place if amputation be performed in the continuity of the bone.

Myeloid tumours, however, form an exception to the rule that sarcomata of bone call for amputation; such a procedure is rarely called for in them.

If the growth be large and occupy the whole thickness of the bone, a free excision of the affected area will suffice ; when the growth is in the articular end, a partial excision of the joint will be called for. When, however, the growth is small and only occupies a small part of the thickness of the bone, so that sufficient bone will be left to bear the weight of the body, it is not even necessary to excise ; the growth may be scraped out without much fear of a recurrence, though it is well to take away a thin slice of the wall of the cavity if possible.

The **prognosis** in all these tumours, if left to themselves, is very grave. With the exception of the myeloid sarcomata they are always dangerous to life. The result of operation is more favourable on the whole than in carcinoma, except in the case of melanotic sarcoma and the osteo-sarcomata, which are extremely malignant forms. In the case of the other forms recurrence, though not infrequent, is often only local, and the secondary tumours may be removed again and again as they appear. In all cases a wide sweep must be made, and a considerable amount of the tissues around must be taken away ; there must be no attempt to shell the growth out of its capsule. The treatment for the mixed forms, such as myxo-sarcoma and fibro-sarcoma, is the same as for the others.

GENERAL POINTS CONCERNING THE TREATMENT OF MALIGNANT TUMOURS.

What has been said above will serve to indicate the main lines of treatment to be adopted for malignant tumours in general. The details of individual operations for the removal of malignant tumours are fully discussed in connection with the various organs and parts of the body in which they occur. But there are a number of points applicable to operations for malignant disease in general to which it is well to refer here.

EXPLORATORY INCISION FOR DIAGNOSIS.—It is not always easy to be certain of the diagnosis, especially when the tumour is deep-seated, and the appropriate operative procedure cannot be undertaken until the nature of the tumour is known. When the tumour is superficial it is easy to remove a suitable portion of the growth and subject it to microscopical examination. When, however, the growth is more deeply seated, it may be necessary to cut down upon the tumour in order to ascertain its real nature.

In making an exploratory incision in a case of suspected malignant disease, the possibility of infecting the wound from the growth and of disseminating the disease must never be lost sight of. To cut through presumably healthy tissues, and then to cut into and remove a portion of a malignant tumour, means that the cells of the malignant growth will certainly be scattered over the surface of the wound and may infect it if the wound be sewn up, as was frequently done at one time.

If a portion of the tumour be removed for examination at one operation, the wound then closed, and another radical operation be undertaken at a later date when the nature of the disease has been revealed by the microscope, the probability will be that many new points of growth will have already developed and that the infection will have become disseminated over a wide area. Hence, in making an exploratory operation it is most important to avoid infecting the healthy portions of the wound with material from the tumour, and not to allow any long time to elapse between the exploration and the radical operation, if one be decided on. It is only when a radical operation is possible, should the tumour turn out to be malignant, that an exploratory incision into the mass is allowable.

If it can be avoided, no tumour suspected of malignancy should be incised *in situ*; the whole tumour should be removed before incising it. A doubtful tumour of the breast, for example, should be cut out entire and examined outside the body. Even then it is impossible to be sure that lymphatic vessels containing tumour cells may not be cut through; but the risk of infecting the wound is very much less than if an incision were made directly into the tumour itself. When it is not feasible or advisable to remove the tumour in the first instance and examine it outside the body, there may be enlarged glands in the neighbourhood which can be taken away and subjected to microscopical examination. All instruments or gloves employed in this preliminary operation should be looked upon as probably infected, and if a further operation be proceeded with at the time, fresh instruments and gloves should be used. The exploration should be followed by the radical operation, if it be decided to carry that out, with the least possible loss of time. Hence, leave should be obtained to proceed with this forthwith after the exploration has been made. It is well to have a pathologist present at the exploration, who will make a rapid section and give a microscopical diagnosis of the tumour on the spot. As a rule, this only means a short delay, during which the patient can be kept lightly under the anæsthetic.

OPERATIONS.—After the true nature of the tumour has been determined, the question of the most suitable operation arises. The operations done for malignant disease may be divided into three large groups—namely: (1) Radical operations, performed with the view of ridding the patient of the disease altogether; (2) Partial operations, with the view of relieving the patient of a source of local pain or distress; and (3) Palliative operations, in which the tumour itself is not interfered with, but some of the troubles to which it is giving rise are relieved.

Radical Operations.—The essence of a radical operation is to remove along with the tumour a considerable area of the surrounding tissues, so as to take away as widely as possible the areas along which the disease naturally spreads.

The difference between radical operations for carcinoma and sarcoma respectively depends on the mode of spread of the disease in the two cases. In both the incisions should pass through healthy tissues at some distance from the disease ; in both any organ in which the tumour started should be completely removed; and in both, if glands be infected, a similarly free removal of lymphatics and glands is indicated. A difference arises, however, in the two forms as regards the latter point. In the case of sarcomata the glands need only be removed when they are evidently affected; in carcinomata the neighbouring lymphatic area must be cleared out in any case A radical operation should be recommended when it is possible to remove all the visible disease with a reasonable chance of non-recurrence and of prolongation of life, and without such mutilation as to make life unendurable. It is unnecessary to remark that the patient should never be advised to submit to what purports to be a radical operation unless the surgeon has every reason to believe that he can remove all the visible disease; but it frequently happens that, while this is possible, the operation may probably be followed by early recurrence, or certainly by most serious mutilation. A good example of such a case as this is an operation for cancer involving the larynx and pharynx. Apart from the great probability of early recurrence, the miserable condition in which the patient will be left must be taken fully into account. If he be well-to-do, and able to have the necessary attendance, and if his pursuits be intellectual, he may be fairly content to live under such conditions ; but a man without financial or intellectual resources will suffer so greatly that a temporary prolongation of life under such circumstances offers no real recompense for the sufferings entailed by the operation. The patient ought always to be fully informed of the extent of the operation, the chances of recurrence, and the final functional result, before he comes to a decision, and this decision should be left to him; the surgeon should content himself with placing the facts fully before him.

There is no method except operation by which malignant disease other than rodent ulcer can be eradicated. Rodent ulcer is a form of local malignant disease with a distinct life-history, and is in many instances apparently cured by radium. There is no evidence, however, that any of the other forms of malignant disease can be cured by this or any other substance, and it is unjustifiable to subject a case favourable for operative treatment to any other method in the first instance.

Partial Operations.—It is never desirable merely to cut away a portion of a tumour, but it is sometimes well worth while to remove a primary growth, even though irremovable secondary growths may be present; similarly it may sometimes be advisable to remove secondary growths that are causing suffering, even though the primary growth cannot be excised. These statements, however, are subject to the qualification that it is not advisable to remove a mass which is likely to recur *in situ* almost at once. A good example of this may be seen in cases of cancer of the tongue of comparatively limited extent, in which there is extensive involvement of glands that cannot be removed. In a case like this the patient's sufferings are mainly due to the growth of the cancer in the tongue, and much pain and distress may be saved by removing the disease in the tongue without attempting to remove the infected glands. It is also sometimes possible and advisable to remove an ulcerating cancer of the breast so freely as to make immediate recurrence at the site of operation improbable, although the co-existing glandular infection may be so extensive that there is no hope of ridding the patient of the disease. It also happens not infrequently that a cancer of the intestine causes obstruction, but can be excised though there are secondary growths present which cannot be got rid of; here an enterectomy may save the patient much suffering and discomfort. It is important, however, to be quite sure that operation is for the benefit of the patient before such partial procedures are undertaken.

Palliative Operations.—When the tumour is inoperable, the condition of the patient may sometimes, nevertheless, be improved by operations in which the disease is not interfered with.

The best example of operations of this type are the various short-circuiting operations done in connection with the intestinal tract—for example, colostomy for rectal cancer, gastro-jejunostomy for pyloric cancer, or tracheotomy for larnygeal cancer.

Sometimes malignant disease gives rise to intense pain which does not yield to sedatives, and benefit may be derived by dividing the sensory nerves concerned, or even by the division of the posterior spinal nerve roots. Another example of an operation designed to improve the condition of the patient without direct interference with the growth is the attempt to cut off the circulation to the affected part and so to starve the growth. Thus in cancer of the tongue, the circulation through the lingual arteries may be obstructed by injecting boiling water into them; this plan has occasionally resulted in a remarkable improvement.

THE TREATMENT OF INOPERABLE CASES.—When a case is unsuitable for a radical operation, partial or palliative operations will be adopted if they are suitable; but in addition it is often well, if only for the patient's peace of mind, to adopt any measures that may arrest or delay the progress of the growth, and it is here that radium, X-rays, and other palliative measures are useful. These measures sometimes appear to delay the progress of the disease, and they may relieve the patient's sufferings considerably, while they frequently give hope to patients and their friends, and thus alleviate the anxiety inseparable from a case in which further operative treatment has been abandoned. Many remedies for inoperable cancer have been introduced, but the majority of them are useless; there are some, however, which are worth mention.

Radium is of great value in rodent ulcer, and claims are being made for it in other forms of malignant disease ; as yet, however, there is no clear evidence that it has any permanent value in these cases. It is quite reasonable, however, to employ it for inoperable cases, and when large supplies of radium can be obtained, and it can be brought into close contact with the malignant disease, good results may follow. At the present time the supply of radium is small and is in the hands of only a few persons. It is therefore unnecessary to go into details as to its method of application.

The use of **X-rays** is on a similar footing. Good results occasionally follow their use in superficial cancers ; for example, some of the disseminated nodules over the chest in cancer of the breast may dwindle and even disappear. But the rays are apparently unable to penetrate and destroy cancer cells situated in deeper parts. Nevertheless, a course of X-ray treatment may be of distinct value in obtaining healing of an ulcerating surface, and delaying the spread of the disease. The pain from which the patients suffer is often relieved by the rays.

A **vaccine** made from the micrococcus neoformans has been introduced, and in some cases marked by severe cachexia the general condition of the patient has improved noticeably under its use ; we cannot say, however, that we have observed any definite action on the growth itself.

Coley's Fluid.—Acting on the observation that in some cases sarcomata improve and even disappear entirely after an attack of erysipelas, Coley introduced a fluid composed of a mixed cultivation of streptococcus erysipelatosis and micrococcus prodigiosus, in which the organisms have been killed by heat. The injection of this fluid into the tumour or into other parts of the body has been followed by the disappearance of the growth in a certain number of cases, while in other instances no effect has been produced. The growths that have proved most amenable to the use of Coley's fluid are spindle-celled sarcomata.

The injections, commencing with a dose of half a minim, must be made with strict antiseptic precautions. This dose usually only produces a slight malaise, but there may be severe constitutional disturbance in susceptible patients, the temperature rising to 103°, with headache, rigors, and all the symptoms of septic absorption, while there is swelling, redness, pain, and tenderness at the seat of the injection ; if, however, the injection has been made with full antiseptic precautions there is no risk of an abscess forming. When there is no reaction, the dose may be repeated next day, preferably into some other part of the body ; on the third day half a minim may be injected into the tumour and another half into the flank. From this point onwards, the dose may be increased by a minim a day until a reaction occurs ; this usually takes place about the end of the first week. The injections must now be governed by the temperature, the object being to get a well-marked rise of temperature after each injection without unduly exhausting the patient. The maximum dose is about fifteen minims, and when this has been reached, two or three injections a week will suffice. If it be necessary to discontinue the treatment, in order to enable the patient to recover from its effects, the dose given on resuming should be slightly smaller than that last injected. The treatment should be continued until the tumour has disappeared entirely or until it is certain that no benefit is being derived from it.

The operation of **oöphorectomy** was introduced by Sir George Beatson of Glasgow for inoperable cancer of the breast; it is founded on the view that there is a definite functional connection between the ovaries and the breast, and there is no doubt that cancerous masses in the breast have disappeared in several instances after removal of the ovaries. Unfortunately, however, this disappearance seems to be only temporary, and in practically all cases, so far as we are aware, the disease has ultimately recurred.

Thyroid extract has also been used in inoperable cases of cancer, either in conjunction with Beatson's operation or alone. Here again, temporary improvement has followed its use in some instances, but in the majority of cases, no effect whatever is produced.

Anodynes.—Apart from endeavours to arrest the spread of inoperable cancer the surgeon can do little but alleviate pain, which is often distressing and continuous. The most efficacious drug is morphine, and the doses must be regulated by the symptoms. Once commenced, it is often impossible to discontinue its use, and it should not be commenced until all other remedies have proved useless. The neuralgic pains can often be relieved by hygienic measures, and the coal-tar series of drugs are often very valuable—for example, aspirin in fifteen-grain cachets, or phenacetin in doses of ten grains. A good formula for the latter is:

Phenacetin	gr. v-x
Sodii bromidi	gr. x
Tr. belladonnæ	♏v
Mucilag. tragacanth.	ʒj
Aq. chloroformi . . .	ad ℥j

BENIGN VARIETIES.—The **Myxomata** are tumours consisting of embryonic connective tissue in which are found the characteristic branched ramifying cells, and often also a large proportion of the round variety. They contain elastic, fibrous, and fatty tissue, and possess but few capillary blood-vessels. They are encapsuled, nodular, and soft, and yield a gummy mucous fluid on scraping. They are simple; they do not tend to recur if properly removed; they grow in the fat, in the subcutaneous and intermuscular tissues, in the skin, mucous membranes, nerves, salivary glands, etc., and they are perhaps most common in the parotid region. They are slow-growing, mobile, semi-fluctuating, and, in the case of the nerves, often multiple.

The **treatment** is to remove the myxoma and its capsule, cutting through the healthy tissues beyond.

The **Fibromata** consist of fully formed connective tissue and occur in two varieties—the soft and the hard. The **soft** fibroma is more cellular than the hard, and contains delicate fibrous bundles not closely approximated. Its usual seat is the skin, where it appears as molluscum fibrosum. The **hard** fibroma is composed of dense fibrous tissue, showing a concentric arrangement around the vessels which are adherent to the tumour, and remain open when divided, especially the veins. It is nodular, whitish-grey, creaks under the knife when cut, and contains large cavernous venous spaces. It occurs wherever there is dense connective tissue—in the skin, in the connective tissues, especially the fasciæ, in the nerves, periosteum, etc. The fibromata are simple tumours which grow slowly, and are only injurious when they press upon important structures. They undergo various forms of degeneration, leading to calcification, or cystic formation.

Moles are subcutaneous tumours containing a pigment called melanin. They are highly cellular in structure, and opinion is divided as to whether the cells are derived from the deeper layers of the epithelium or the chromatophore cells of the true skin. They may become malignant, with rapid metastasis throughout the body. In some cases this may occur without any obvious change in the mole itself.

Treatment.—The hard fibromata should be removed, and when they possess a definite capsule they may generally be shelled out of it with ease; but in many cases, when they occur in connection with the fasciæ, the capsule is not well defined, and it is necessary to take away this structure along with them. There is no tendency to recurrence after complete removal. The pedunculated molluscum fibrosum can be snipped off, and a very small scar is left. Moles can only be excised; they have no capsule. In removing a large fibroma care must be taken not to cut into its substance, for the large vessels are embedded in the tumour and are unable to retract, and therefore the bleeding may be very severe. The removal of fibromata in the naso-pharynx may be complicated by the most alarming and uncontrollable hæmorrhage if this precaution be neglected. If such an accident should happen, the tumour must be ablated as quickly as possible, when the vessels leading to it will generally contract, and the hæmorrhage will cease spontaneously; even if this be not the case, the bleeding points will be much more readily accessible.

The **Lipomata** are tumours composed of tissue which resembles normal fat and is arranged in lobules with connective tissue between. The cells are somewhat larger than normal fat cells. Sometimes the tumours contain a considerable quantity of fibrous or mucous tissue, and they are met with in two forms. One is termed the **diffuse** lipoma, in which there is a diffuse formation of coarse fat not surrounded by a capsule; it is usually met with at the back of the neck on each side of the spine, or in each anterior triangle of the neck, but it occurs also over the abdomen, the arms, and elsewhere. More frequently, however, the lipomata are **circumscribed**, soft, and lobulated encapsuled tumours; there is often only very delicate tissue connecting the lobules together. They are usually smooth on their deeper surface, and when growing in the subcutaneous tissues they penetrate among the fibrous bands connecting the under surface of the skin with the tissues beneath, so that the skin does not move quite freely over them. They possess a more or less well-defined capsule, out of which they are readily shelled. They occur at all ages and grow slowly; they are met with most frequently in the subcutaneous tissues where fat is abundant, such as the back of the neck, the front of the thigh, the abdominal wall, the arms, the axillæ, the buttocks, etc.

Treatment.—(*a*) **Of the Encapsuled Variety.**—These growths are readily removed, and shell out of their capsule without any trouble, but care must be taken to see that none of the outlying lobules are left behind, as those left will grow again and form a fresh tumour. The best way to remove a lipoma is to squeeze up the tumour forcibly between the thumb and forefinger of the left hand and make the skin very tense over it. Then, on incising the skin, subcutaneous tissue and capsule, the lipoma is projected forcibly through the incision, and its complete enucleation is insured. When lipomata occur in parts subject to pressure, inflammation, leading to adhesions between the tumour and the skin covering it, or the structures over which it lies, is not uncommon; in such cases care must be taken to remove the whole of the tumour, and it is generally best to remove the adherent skin as well.

(*b*) **Of the Diffuse Variety.**—In these cases the question of operation depends on the amount of pain and unsightliness that the tumour causes and on the wishes of the patient. As the mass is not encapsuled it is not possible, as a rule, to remove the growth entirely, and therefore it is likely to grow again; but in many cases considerable improvement both as regards pain and appearance, can be effected by excising as much of it as possible; in doing this care must be taken to avoid damage to important structures, such as nerves, etc.

Chondromata are tumours consisting essentially of cartilage, of which they may embrace all varieties, including the ramified cell form without capsule usually found in embryonic conditions and in some of the lower animals. For the most part the cartilage resembles the normal hyaline variety, but it differs from it in that the blood-vessels penetrate into the cartilaginous nodules. The tumour is composed of an aggregation of nodules of cartilage separated by fibrous tissue, and is encapsuled.

Chondromata form rounded or lobulated tumours which may surround various structures, such as tendons, nerves, or vessels, without actually destroying them. On section they are usually semi-transparent, greyish-blue, firm and elastic, or soft. They occur especially in the phalanges and metatarsal bones, where they are often multiple; in the jaw, in the pelvis, or about the epiphyses of long bones. Sometimes also they occur in soft parts, such as the parotid, the submaxillary gland, and the testicle; but it is a question whether chondromata occurring in the soft tissues are not really chondrifying sarcomata rather than true chondromata. At any rate these tumours are generally malignant in the testicle, and give rise to secondary deposits in the lungs, and the same chondrification takes place there. Chondromata may undergo calcification or fatty or mucous degeneration, leading to the formation of cysts. They grow slowly and cause trouble chiefly by pressure, and they are benign tumours, with the exception of the variety met with in the soft parts already mentioned.

Treatment.—When the tumour is situated in the soft parts, the best treatment is extirpation; the capsule should be removed because of the possible malignant nature of the tumour. When the growth springs from a bone, it may be sufficient to chip it away freely, or, if situated in the interior, to scrape it out without performing amputation; this may be done even in the multiple chondromata of the fingers. Care must be taken to do this as completely as possible, because recurrence is apt to take place from lobules of the cartilage being left behind. Should this happen, enucleation may be repeated, or it may be necessary to amputate if the bone be so much destroyed by the growth as to be useless, as may be the case in a phalanx, for example.

The **Osteomata** are composed of bony tissue, and are met with in two chief forms. The rarer of these is the hard or **ivory** osteoma or exostosis, which is a flat sessile bony mass chiefly occurring on the vertex of the skull, on one of the bones of the face, or in the external auditory meatus; it is of ivory hardness, and is formed of dense compact bone, containing lacunæ and canaliculi, but without proper Haversian canals. The other form is the **spongy** exostosis, which resembles cancellous bone in structure and generally arises in the neighbourhood of the epiphyseal lines. During the period of growth these spongy exostoses are covered with a layer of cartilage, and it is from this part of the tumour that growth takes place. As a rule this cartilage quickly ossifies at the point where the tumour joins the bone from which it arises, and then growth ceases there whilst it goes on at the periphery of the tumour; hence these growths are usually pedunculated, and they vary in size and are nodular on the surface.

Treatment.—The treatment of the **spongy** exostoses is to cut through their base and remove them; if this be done where growth has ceased and cartilage does not exist, recurrence will not take place. Before antiseptic treatment was employed, many patients developed a suppurative osteomyelitis after operation, and either died or had to lose the limb; great care must be taken in the aseptic management of the wound.

The small **ivory** exostoses on the outside of the skull are seldom of sufficient size to require operation. Their removal is always difficult and dangerous because, owing to their density, the force required to chip them off sometimes fractures the skull. Hence it is best to leave them alone as a rule, but, should they press on the eye, ear, or other important parts, or grow internally, it may be necessary to undertake their removal. If the growth be small, it may be possible to encircle the tumour by a large trephine, and the exostosis and the base from which it springs can be removed entire by cutting through normal bone all around. In the larger growths this is impossible, however, and the best way of removing them is to drill a number of holes through the base of the tumour with a dental drill, and then to join these together with a saw and thus complete the removal; in the ear it is sometimes possible to break them off by means of a sudden smart tap, after their base has been drilled. If the growth be very diffuse, and must be removed, it may require more than one operation for its satisfactory treatment.

Bony growths which do not properly come under the heading of osteoma are also met with elsewhere; among these may be mentioned the bony growths which occur from irritation in the adductors of the thigh in riders, or in the deltoid muscle in soldiers; they are dealt with in connection with the affections of muscles.

TUMOURS COMPOSED OF THE MORE COMPLEX TISSUES.

Amongst the tumours composed of more complex tissues are those consisting of muscular tissue or myomata, of nerve tissue or neuromata, of blood-vessels or angiomata, of lymphatic vessels or lymphangiomata, and complex tumours and cysts.

Myomata are composed of unstriped muscular fibre, and are met with where unstriped muscular fibre is normally present—*e.g.* in the uterus, the prostate, the wall of the œsophagus, the stomach, and the intestines. In the latter situation they generally project into the lumen of the gut, forming pedunculated polypi, covered by the mucous membrane. Myomata may be single, but they are more often multiple; they form round lobulated tumours with an investing fibrous capsule, and on section they resemble fibromata except that they are of a purplish colour. They are generally very vascular, especially at the periphery, where large venous sinuses are numerous. They occur in adults, and cause trouble from their size and their tendency to bleed.

Treatment.—This depends mainly upon their situation, and the consideration of the treatment must therefore be considered in connection with the particular organs in which they occur.

Neuromata are composed of nerve tissue and are very rare, if, indeed, they ever occur; the tumours generally spoken of as neuromata are inflammatory thickenings occurring in the course of nerves, such, for example, as the enlargements at the divided ends or tumours, such as myxomata, fibromata, or sarcomata, occurring in the neighbourhood of and involving nerves. In connection with neuromata may be mentioned the **gliomata**, which occur in the central nervous system, and in the retina, and are composed of neuroglia. They are often vascular, and as a rule they are not malignant except locally; the gliomata which occur in connection with the retina are more malignant, however, and possibly ought to be included among the sarcomata.

The **treatment** of neuromata belongs to that of the affections of nerves. A glioma should be removed whenever possible; the subject is dealt with in connection with tumours of the brain.

Angiomata or nævi are composed of vascular tissue, and the essential element in them is the formation of blood-vessels. The latter are partly of new formation and are partly pre-existing vessels much dilated and thickened. These tumours are divided into two groups—the simple or capillary, and the cavernous or venous.

In the **capillary** angioma the vessels are distinct and have well-defined walls, and the tumour consists of a mass of dilated tortuous capillaries, derived not only from dilatation of old capillaries, but also from the formation of new ones. There is no definite capsule, and therefore the tumours are not clearly marked off from the surrounding tissues, their outline being irregular and somewhat lobulated. They occur usually in the skin, and may be either upon its free surface or in its substance, and they may spread from the skin to the subcutaneous tissue. The tumour generally presents a bright red colour, but it may be somewhat bluish where the circulation is slow.

The **cavernous** angioma, or venous nævus, occurs in the skin, subcutaneous tissue, muscles, etc., and is made up of large spaces communicating with the blood-vessels and separated from each other by septa of unequal thickness containing fibrous tissue, remains of the original tissue, elastic fibres, striped and unstriped muscle, fat cells, vasa vasorum, lymphatics, and nerves, the blood spaces themselves being lined with endothelium. The great majority of these venous nævi are congenital (in fact both kinds of nævi generally are), and they may disappear as the child grows older, or they may increase in size; the latter is more frequently the case with the subcutaneous or cavernous form. Nævi sometimes undergo cystic degeneration, the communication between the blood spaces and the vessels being obliterated, and the former then undergoing dilatation, so that cysts of variable size are formed.

Treatment.—The treatment of nævi may be divided into (1) excision, and (2) the use of methods which aim at setting up inflammation in the vessels so as to procure first thrombosis and ultimately atrophy of the vascular growth.

Excision.—Excision is certainly the best possible method of treatment, and should be adopted in all cases where it is possible to carry it out. It presents the following great advantages over all other methods. It is certain and rapid in its results, the affection being cured permanently within a fortnight ; there is no pain attending the after-treatment ; no frequent change of dressings is called for, and therefore there is not the liability to septic infection which is almost inevitable where the opposite is the case. The cases most frequently met with in practice are the moderate-sized capillary nævi, with or without affection of the subcutaneous structures, and this form is certainly best treated by enclosing it in an oval incision well free of the growth and cleanly excising it. A large nævus may not be suited for excision either because its size renders the operation formidable from loss of blood, as may be the case in infants, or because there may be difficulty in bringing the edges of the wound together. In the former case it is advisable to adopt one of the methods described below for procuring thrombosis, and when enough of the tumour has thus been obliterated the rest may be excised. In the latter case most superficial nævi can be satisfactorily treated by excision followed by undermining of the skin so as to secure apposition of the cut edges. When the area is too extensive for this, Thiersch's skin grafting is preferable to the scarring that inevitably follows other methods. Even on exposed parts the scar left by the operation is not so noticeable as that which results from other modes of treatment. A superficial nævus will rarely be found too extensive for treatment by excision, especially if Thiersch's grafting be employed ; several partial operations may be required.

When the surgeon has to deal with a deep-seated cavernous nævus, which is fairly limited and does not involve any important structure, complete excision should also be attempted. There is no particular danger in excising a nævus. It should be done strictly antiseptically, and if care be taken to cut well beyond the tumour, there is no bleeding of importance, the vessels actually dilated being those within the growth itself ; those that are divided in the operation are merely the isolated afferent and efferent trunks, which are easily secured as they are cut. It is important not to cut into the growth, as otherwise the hæmorrhage may be profuse and controlled only with the utmost difficulty. When, however, the nævus is partly superficial and partly deep, involving structures which cannot be readily removed, such as the lip, or even more important deeper structures, then excision is not advisable, and other methods must be employed.

Electrolysis.—In using electrolysis for nævi, different effects are produced by the positive and negative poles ; at the positive pole a firm, hard, and readily organised clot forms, whilst at the negative it is soft and frothy, and of little value in the formation of new tissue. Hence it is the positive pole which is chiefly relied upon to produce the local effect. Several needles connected with this pole should be introduced into the swelling at various points, especially in the neighbourhood of the veins which leave it. The needles should be insulated by means of shellac or guttapercha, or some similar material, right up to within a quarter of an inch of the point, and should be pushed into the nævus until the insulated portion lies in the hole in the skin. If the needle be not properly insulated where it passes through the skin it will produce a slough, which will not only leave a scar, but may also be a point of entrance for septic material into the clot. Care must be taken that the points of the needles do not approach too near the surface of the tumour, whether it be skin or mucous membrane, for, even if they do not actually perforate it, they may lead to sloughing and subsequent sepsis ; this is particularly

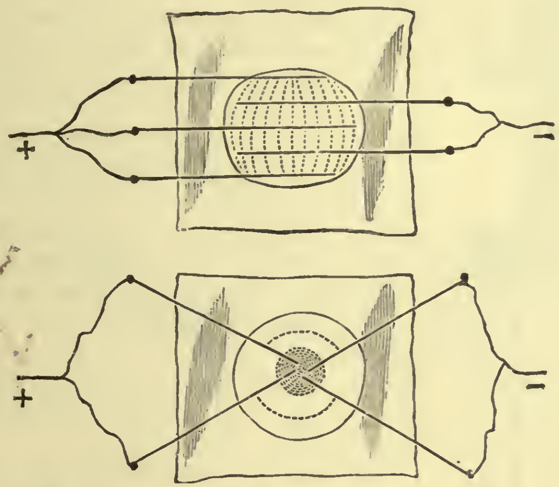


Fig. 60.—Methods of inserting the Needles in Electrolysis of a Nævus. In the upper figure the needles are parallel, and the current is evenly diffused over a large area ; this is the correct method. In the lower figure the current becomes concentrated at the centre of the tumour, which is therefore liable to slough. The periphery is hardly acted upon at all. (*Lewis Jones.*)

likely to happen if the points of several needles be close together. If more than one needle be introduced into the nævus, care should be taken to keep them parallel to each other, so as to ensure equable diffusion of the current and avoid sloughing (see Fig. 60). A useful and ingenious handle has been suggested by Dr. Lewis Jones for this purpose (see Fig. 61). By its means the needles are kept parallel, while both positive and negative electrodes can be inserted into the tumour if desired. The needles should be rendered aseptic by boiling ; it is well not to immerse them in strong carbolic lotion, as that destroys the insulating material, and, if steel needles are used, an immersion in a 1 in 500 perchloride solution would damage the metal. As a rule platinum needles are to be preferred ; the only drawback is that it is impossible to get a good sharp point to them. An alcoholic solution of shellac should be at hand with which the needles can be painted to renew any of the insulation that has become faulty.

It is especially necessary to see to this if steel needles be used, as a permanent black mark is liable to occur if any uninsulated portion lies in contact with the skin. After the needles attached to the positive pole have been inserted in the manner just described, a large flat pad attached to the negative pole and moistened with salt solution is placed on the skin either over the spine or somewhere in the neighbourhood of the nævus. The pad must be moved from one point to another as the electrolysis proceeds, so that it shall not act too long at one spot; if it does, a slough may result. In large nævi both poles may be buried in the tumour, the negative pole being attached to a single needle insulated as described above, which is also pushed into the swelling. For this purpose the handle figured below (see Fig. 61) is specially useful. The strength of the current should be from 20 to 30 milliampères, but, when three or four needles are used, 30 to 40 may be used. The current should be continued for about ten minutes; the best criterion as to when to discontinue it is perhaps that the nævus is felt to become firm. Before withdrawing the needles, the current should be reversed for a few seconds, as otherwise those connected with the positive pole adhere firmly to the tissues, and bleeding results from their withdrawal; this is, however, not of any real moment, light pressure being sufficient to check it.

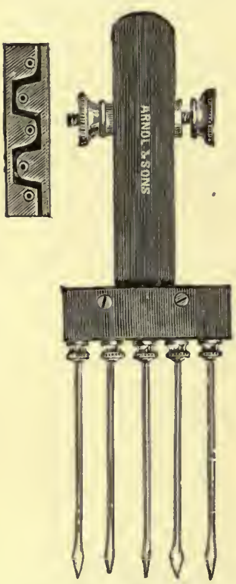


FIG. 61.—BIPOLAR FORK ELECTRODE. The needles are alternately positive and negative, and are screwed in. The smaller figure shows the method of insulation. (*Lewis Jones*.)

The skin should be thoroughly disinfected before the operation (see p. 100), and after it a little salicylic wool may be applied over the puncture, fixed on with collodion, and allowed to remain till healing has taken place. The electrolysis causes a good deal of pain, especially at the make and break of the current, and when its strength is increased, and it is therefore well to employ a general anæsthetic. The current should be increased very gradually, and when the operation is completed it should be diminished gradually and not shut off abruptly, as otherwise considerable shock may be caused. Similarly, before reversing the current, its strength should be decreased gradually almost to nothing. When the nævus is situated over the fontanelle of a young infant, a watch must be kept on the pulse as the current is increased. If any sign of shock be noticed, the current must be diminished or shut off entirely.

As the result of the electrolysis the nævus becomes hard, and this hardness may sometimes last several weeks before it disappears entirely. If the nævus be of any size, one sitting is rarely sufficient for a cure, and therefore the application is repeated as soon as the hardness has subsided sufficiently to show what portion requires further treatment; at first this may be done at intervals of three weeks. After three or four sittings, however, the greater part of the nævus will have become firm, and then longer intervals must be allowed, because it is impossible to judge how much remains to be done until the hardness has almost disappeared.

Electrolysis may be conveniently combined with temporary strangulation of the blood-vessels of the part, especially in nævus of the lip. After the patient has been anæsthetised the special forceps shown in Fig. 62 are applied to the lip, as shown in Fig. 63, so as to obstruct circulation through the nævus completely. The blades of the forceps should be covered with india-rubber, not only because this renders them less likely to injure the tissues, but because there is a risk of a serious burn followed

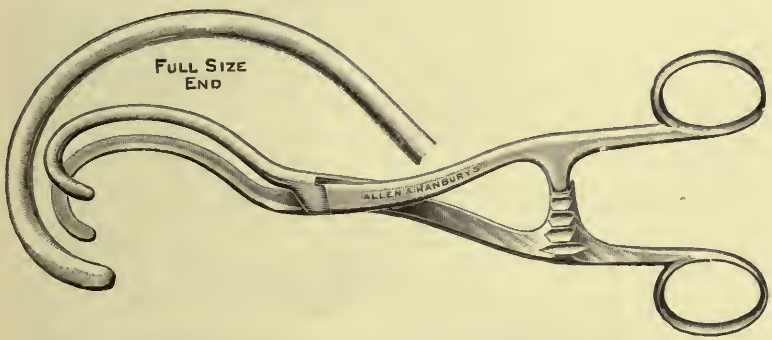


FIG. 62.—COMPRESSION FORCEPS FOR USE IN ELECTROLYSIS OF NÆVUS OF THE LIP.

by troublesome sloughing if the forceps come into contact with either of the connecting wires. After the forceps have been applied, the nævus is electrolysed in the ordinary manner with several platinum needles, which may be connected to one or both poles of the battery. After five to ten minutes the circuit is broken, but the forceps are left on for another five or ten minutes. By this means the coagulum around the electrodes spreads throughout the vascular channels near it, and is not washed away into the general circulation. A greater effect can thus be got than by simple electrolysis; weaker currents can be employed, with a correspondingly smaller risk of sloughing. For a very small nævus it is sometimes possible to use an ordinary pair of tongue forceps or a couple of intestinal clamps, but the blades must always be insulated with india-rubber. In other situations the same principle may be employed. In the case of a nævus situated over a bone—for example, on the forehead—a firm india-rubber ring held securely in position by tapes tied at the back of the neck answers the purpose very well.

Caustics.—Besides the extensive and important nævi, there are small superficial capillary stains, of small size and insignificant proportions, in which it is not worth while to have recourse to excision. The particular method to be employed will depend to a great extent on the size and situation of the tumour. When there is a superficial nævus affecting only the surface of the skin, the application of an irritant will suffice. The most popular is the solution of *ethylate of sodium* (one part to eight of ethylic alcohol), which is painted over the part once a day for three or four days, and which usually gives rise to sufficient inflammation without causing marked scarring. It causes a little pain at the time of application, but this passes off immediately; no dressing is required. The small crust that forms after the application is allowed to dry up

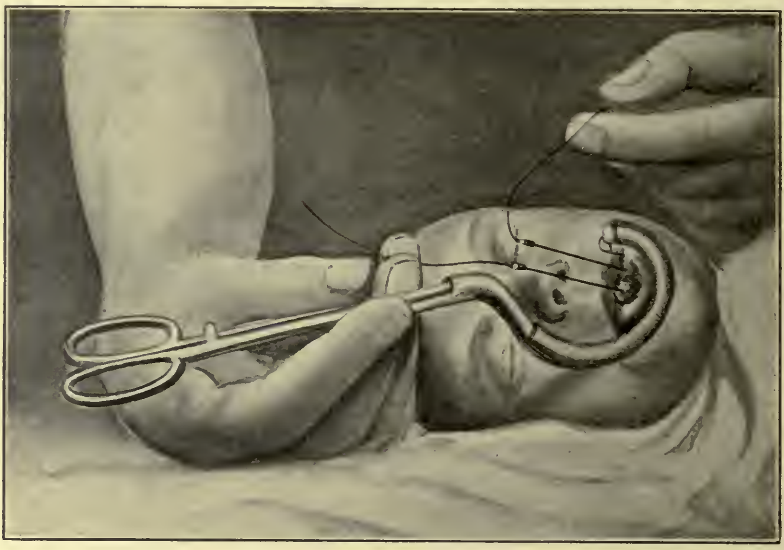


Fig. 63.—Method of Treating Nævi by Compression and Electrolysis. Drawn from a photograph.

and drop off, when the nævus will be found to be cured if the application has been sufficient; the application may be repeated should any of the nævus tissue remain. *Nitric acid* is sometimes used, but it leaves a distinct scar and is decidedly painful both at the time of application and subsequently.

A good method of treatment for very tiny nævi or red points is to draw through them a needle armed with a very fine silk thread which has been dipped in liquefied *carbolic acid*. The skin all around where the needle enters should be smeared with sterilised vaseline, so that the thread does not come into contact with it, as otherwise it would cause a burn and give rise to a scar. The thread is pulled right through the nævus, and then pressure is applied for a little until the bleeding stops, and the puncture is covered with collodion. The old method of vaccinating upon these minute nævi is a good one if they be small, superficial, and in a suitable situation.

The Actual Cautery.—This is preferable to the use of chemical caustics in the majority of cases, and yields very satisfactory cosmetic results on the whole when it is desired to obliterate a small spider nævus with a central red spot from which a number of small vessels radiate in stellate fashion. When the nævus is situated upon the face the patient should be placed in such a position that the surgeon has complete control of the head, so that if the child moves there is no risk of cauterising normal tissues. The head is steadied between the surgeon's wrists so that his hands and the patient's head move together, and a fine electro-cautery heated almost to whiteness is plunged rapidly into the centre of the nævus and withdrawn immediately. There is no need to administer an anæsthetic to these cases, as the pain is momentary and quite slight. The puncture can be sealed with a drop of collodion or friar's balsam.

Fig. 64.—Multiple Nævi in Course of Treatment by the Galvano-Cautery. Towards the umbilicus complete cicatrisation of the nævus has been obtained. Further down on the abdominal wall another nævus shows the punctate cicatrices caused by the first application of the cautery.

More extensive nævi require the administration of an anæsthetic. In these cases the cautery should be at a dull red heat and should be thrust completely through the nævus. When nævi treated thus are situated over important structures—*e.g.* a nævus of the eyelid—it is important that the point of the cautery should not penetrate too deeply. To obviate this, the skin containing the nævus may be pinched up between the left thumb and forefinger so as to draw the nævus away from the subjacent structures. It is easy to ascertain when the cautery has passed through the dermis, as this structure offers a definite resistance which ceases suddenly as penetration occurs. The cautery punctures should be about a quarter of an inch apart over the whole surface of the nævus; care being taken to destroy any vessels that can be seen entering or leaving it. If the nævus be too extensive for the punctures to be made all over its surface, they should be made around its margin, especially at the points where the growth seems to be most active. The best dressing for these cases is friar's balsam painted directly on to the surface of the nævus; a thin layer of wool is then applied and some more of the balsam painted on. The dressing will fall off in about ten days and the punctures will be found healed. At this stage the nævus presents a speckled appearance, with white or pinkish spots scattered over its bright red surface. At the second operation another series of punctures is made between the first, and the process is continued until the whole of the nævus has become converted into scar tissue. This method is particularly applicable where an excision of a wide area of skin is inadvisable—*e.g.* when a nævus nearly encircles a limb, lies over a joint, or is in the neighbourhood of the eyelids. Little contraction is caused, the resulting scar being often only slightly larger than the original nævus.

FIG. 65.—METHOD OF APPLYING THE SOLID STICK OF CARBON DIOXIDE.

Freezing. — This method has only been introduced recently. Although there is usually a certain amount of tissue destruction, the efficacy of the method depends upon the reaction which follows the freezing, and thus differs from the effect of the actual cautery. Liquid air is often employed for the freezing, but it is difficult to store and not very manageable in use. Probably the best agent is solid carbonic acid, which can be obtained in the form of a solid stick and can be cut to any shape. This has the additional advantage that pressure can be combined with extreme cold ($-79°$ C.). The carbonic acid can be purchased as a liquid in the large cylinders used for the preparation of mineral waters; on opening the tap of the cylinder the liquid carbonic acid escapes, and evaporates so quickly that intense cold is produced, which freezes the liquid into a soft snow.

A simple method of preparing the solid stick is described by Morton. A huckaback towel is rolled round a wooden ruler, and the latter is withdrawn from the tube of towelling, which is destined to act as a mould for the carbonic-acid stick, and one end of the tube is closed by a loosely fitting cork. The gas cylinder is placed upon a table with the delivery pipe pointing downwards, and the foot of the cylinder raised about six inches so as to allow the liquid contents to flow towards the tap; the open end of the towel mould is then placed over the delivery pipe and bandaged firmly in position. The bandage must be carried round the whole length of the tube, then lengthwise along the tube round the outlet valve of the cylinder and over the cork so as to prevent the tube being blown off ; two or three bandages are necessary. The stopcock is now opened and the carbonic acid allowed to escape fairly rapidly, the towel tubing and the cork forming a mould in which the loose carbonic-acid snow is compacted into a firm cylinder, the porous towel and bandage allowing excess of gas to escape and preventing an explosion. After the gas has been running freely for about a minute or a minute and a half, the stopcock is closed. The brass cock has become intensely cold, and any attempt to handle it with the bare hands will produce severe frostbite. A pair of gas tongs or a thickly folded duster should therefore be used. The bandage is now removed and the towel unrolled. With a little practice it will be found possible to prepare a solid cylinder of carbonic acid six inches long and about three-quarters of an inch in diameter, sufficiently firm to be cut to any shape. This cylinder must not be handled with the bare hands, but a couple of thicknesses of lint or a folded towel are quite sufficient to protect the operator.

The end of the cylinder is pared so that its cross-section is a little larger than the area of the nævus to be treated and is pressed firmly on to the surface of the nævus and kept in position for from twenty to forty seconds. On removing the stick a deep sharply-cut depression is seen in the midst of a white frozen area. In a few seconds the tissues thaw and the depression becomes obliterated. No anæsthetic is needed for this procedure ; the actual application is almost painless, although subsequently there is some slight burning pain in the part. After freezing, a sharp reaction takes place in the part, accompanied by distinct blistering or even slight superficial ulceration, but no after-treatment is required beyond a simple dusting powder. This method is particularly suitable for superficial nævi and port-wine marks. It can also be used for warts and small cutaneous tumours. The stick of carbonic acid can be kept exposed to the air for about a couple of hours ; if it be desired to preserve it longer it may be slipped into an ordinary Thermos bottle, the neck of which is plugged loosely with cotton-wool.

When only a few cases have to be treated, a stick of solid carbonic acid can be prepared rapidly in the cylindrical moulds provided with a cap and a piston which are sold for the purpose. The carbonic-acid snow is collected, either in a tubular wash-leather bag provided with clips, which can be undone so as to throw the whole bag widely open, or, failing this, in a loose bag made by wrapping an ordinary towel around the outlet pipe of the cylinder. The snow is then put into the cylindrical mould and compacted together with the piston rod. Snow is added in small quantities and hammered down into the mould by the piston until a sufficient quantity has been obtained, when, by taking off the cap, the stick can be readily forced out of the mould with the piston.

Radium has also been found effectual for port-wine stains, but a considerable quantity and a long exposure are required.

Lymphangiomata are tumours composed of lymphatic vessels of new formation, and it is often very difficult to differentiate them from lymphangiectases or varicose lymphatics; they are congenital circumscribed tumours. Three **varieties** are described:

(1) The **simple lymphangiomata** consist of dilated lymphatic vessels of the size of capillary blood-vessels; tumours of this nature occur in the perineum, in the sacral region, in the axilla, etc. In some cases the dilated vessels are considerably larger, as is seen in the tongue in one form of macroglossia, and also in the lips, where it goes by the name of macrocheilia.

(2) **Cavernous lymphangiomata** are spongy masses composed of lymphatic vessels, very closely resembling venous nævi in structure. They are found in the neck, in the sacral region, the lips, etc., generally in the subcutaneous tissues, but often deeper.

(3) **Cystic lymphangiomata** are congenital agglomerations of cysts of various sizes which may or may not communicate with each other or with lymphatic vessels. They are seen most frequently in the neck, where they have received the name of *hydrocele of the neck*; they are also met with in the perineum, buttocks, thorax, etc.

Treatment.—Operative interference, such as excision, used to be followed by suppuration in the lymph spaces, followed by very serious results. This risk can be easily avoided nowadays by care in the management of the wound. In the majority of cases *electrolysis* is the best treatment (see p. 256). In the cystic forms, injections of iodine or undiluted carbolic acid are employed in the same way as for hydrocele of the tunica vaginalis. In the smaller forms excision is frequently practised, but great care must be taken to ensure the asepticity of the wound.

Lymphadenoma.—The causation of this disease is still uncertain and many authorities consider that it is allied to true tumour formation. It may, however, be an infective disorder and will be described in the section devoted to diseases of the lymphatic glands (see Vol. II.).

Lympho-sarcomata are composed of lymphatic tissue, and occur primarily in glands or in parts where lymphatic tissue is normally found; they present a delicate reticulum with round cells entangled in it. The typical lympho-sarcoma is a very malignant tumour indeed. It occurs generally in the neck or the axilla, and the growth soon spreads beyond the gland capsule and infiltrates the tissues around. Adhesion to the surrounding structures soon occurs, and thus a nodular mass is formed composed of a multitude of glands united by adenoid tissue. Other groups of glands soon become involved and, in addition, tumours composed of lymphatic tissue may appear in parts where this is not normally present, as for example in bones. The disease goes on and is accompanied by increasing pallor of the patient, but not at first by emaciation. Ultimately death takes place from exhaustion.

Treatment.—The treatment of lympho-sarcoma is unsatisfactory. Excision of a mass of lympho-sarcomatous glands seldom arrests the progress of the disease, even though the whole of the affected area may apparently be removed. Other glands soon enlarge, and recurrence often takes place in the neighbourhood of the primary growth. Hence, except at a very early stage, or where its situation is such that the growth causes much suffering from pressure upon important organs, excision cannot be recommended ; even at an early stage it is of doubtful value.

Cysts.—This is perhaps the best place to refer to the various forms of cysts ; the true cysts are those of new formation, and are not produced by obstruction of pre-existing canals or by degenerative changes. Cysts may be unilocular or multilocular, and are found in the ovary and in the breast. In the ovary, multilocular cysts form large tumours generally composed of one or two very large cysts, and numbers of smaller ones. The walls are smooth and shining, the contents a clear fluid or a turbid glairy material ; papillary outgrowths are not uncommonly present in their interior. The cysts of the breast are similar in character, but smaller, while the intra-cystic growth may be more markedly developed. Cysts may be the result of degeneration in tumours or they may be due to the dilatation of previously existing cavities, such as sebaceous cysts, hydronephrosis, hydroceles, etc., but these cannot be classed as true tumours.

Complex Tumours.—These may be solid or cystic ; they are congenital, and generally contain a variety of tissues. They are most frequently met with over the sacrum, forming the *sacro-coccygeal tumours*, and may contain bone, connective tissue, muscle, nerves, cartilage, epithelium, etc. ; cysts also are often present. Another form of congenital complex tumour is the dermoid cyst, the lining wall of which is composed of structures resembling skin, containing the skin glands as well as hairs, and often teeth and even bone. They occur in the ovary and in various parts where epithelial structures may have been included during development, more particularly in the neck in connection with the branchial clefts and about the root of the nose or the angular process of the frontal bone.

The **treatment** of these tumours is described in connection with that of the affections of the organs in which they occur.

DIVISION V.

DEFORMITIES.

CHAPTER XIV.

DEFORMITIES AFFECTING THE FINGERS AND TOES.

In this division will be included the various deformities of the extremities (along with scoliosis) which are usually grouped together under Orthopædic Surgery. Deformities in other regions will be discussed in connection with the affections of those regions.

Deformities may be divided into two great groups—congenital and acquired deformities. Of the former we shall only deal with those that can be improved by treatment; those for which nothing surgical can be done will not be described.

The acquired deformities are due to such various causes and a number of causes are so often at work in any given case that it is not possible to group them according to their causes. We shall therefore describe them according to the regions in which they occur.

SUPERFLUOUS DIGITS.

The number of supernumerary digits varies widely; in some cases ten in all have been met with. The condition is usually bilateral and frequently affects both hands and feet. In the foot it is commonest to find a supernumerary toe on the outer side, forming an accessory little toe. In the hand the most usual deformity is an accessory little finger, but an additional thumb is not at all infrequently met with. The degree of development of the supernumerary member varies within wide limits;

sometimes a complete digit is met with—that is to say, there are three distinct phalanges (or, in the case of the thumb, two) perfectly developed. It is very rarely that reduplication of a metacarpal or metatarsal bone also occurs; but if it does, the additional digit then articulates with the carpus or tarsus respectively. The first phalanx of the supernumerary digit is generally attached to the side of the metacarpal bone, either with or without a proper articulation. It is common to find no trace of a joint, the union between the superfluous digit and the metacarpal bone being effected by means of fibrous tissue; in other cases there is a well-formed joint on the lateral surface of the metacarpal bone, furnished

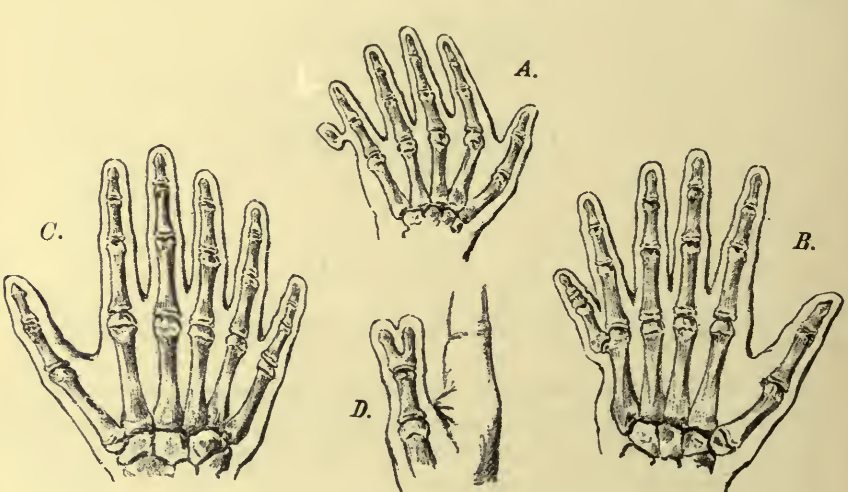


FIG. 66.—DIAGRAMS TO ILLUSTRATE THE FORMS OF SUPERFLUOUS DIGITS. In *A* the connection between the digit and the rest of the hand is of skin and fibrous tissue only. In *B* there is a distinct articular surface on the lateral aspect of the metacarpal bone. In *C* there is a supernumerary metacarpal bone as well as the phalanges. *D*, One form of bifid terminal phalanx.

with articular cartilage, ligaments, etc. In other cases, again, the condition is that of bifid finger or toe, and this is more often seen in the thumb than in the other fingers; the terminal phalanx is split and two complete phalanges may be present, each possessing a separate nail (see Fig. 66, *D*). Frequently, however, the division in the terminal phalanx does not extend through its whole length, but only affects the tip; the base of the phalanx is then undivided.

TREATMENT.—The removal of the supernumerary digit is the only remedy for this condition. It is not usually a matter of consequence if a supernumerary toe be retained, but additional fingers are unsightly and generally ought to be taken away. In order to make sure of the most satisfactory result, operation should be done in early life.

(*a*) *When the digit is quite separate* from its neighbour and is only connected with the side of the metacarpal bone by fibrous tissue (see

Fig. 66, *A*) the result of amputation should be perfect; it is only necessary to make an elliptical incision around the digit where it springs from the metacarpal bone, and then to remove it and the fibrous band connecting it with the bone. With a nicely planned incision and primary union, a level surface will be left showing no trace of the additional finger.

(*b*) *When there is an actual articulation* between the digit and the metacarpal bone (see Fig. 66, *B*) mere removal of the finger is not sufficient. If the articular surface be allowed to remain, a swelling is left upon the side of the metacarpal bone, and this increases as time goes on from growth taking place beneath the articular surface, so that there may be a very unsightly projection by the time adult age is reached. Hence it is necessary to remove both the superfluous digit and the articular surface upon the metacarpal bone to which it is attached. The flaps are so planned that there shall be no excess of tissue left when they are brought together; after the finger has been disarticulated and removed, the articular surface on the metacarpal bone is exposed, and enough bone is gouged away to render the shaft of the bone smooth and uniform in thickness.

FIG. 67.—INCISIONS FOR THE REMOVAL OF A SUPERNUMERARY THUMB.

(*c*) *When there is a supernumerary metacarpal bone articulating with the carpus* (see Fig. 66, *C*), it must be removed along with the finger; when that has been done, enough bone must be removed from the side of the carpus to make the outline of the hand resemble that of the opposite side. This involves opening the wrist joint, and therefore the operation is one that ought not to be undertaken unless the surgeon be certain of his ability to keep the wound aseptic. The æsthetic results, however, are very satisfactory, as the unsightly projection at the side of the wrist can be obliterated and little trace of the deformity left.

(*d*) *In the case of a bifid finger*, especially a bifid terminal phalanx of the thumb (see Fig. 66, *D*), the result of treatment is not so satisfactory. The two portions of the phalanx usually diverge from each other, so that, whichever be removed, the remaining one is out of line with the rest of the limb, and it is very difficult to bring it straight; that, however, must be the aim of the operation. In the first place, the phalanx which deviates most from the axis of the finger (usually the smaller of the two) should be amputated by an elliptical incision over the corresponding side of the digit. The flaps should be cut so as to avoid removing too much skin. If the supernumerary portion be sessile, this may be difficult and the safest way will be to make a free incision along one edge of it and split it open. The bone can then be dissected out, and it will be easy to trim up the soft parts so as to make flaps which meet satisfactorily.

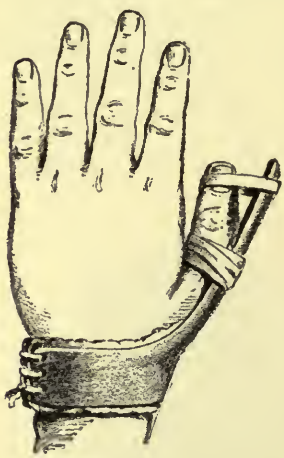


Fig. 68.—Splint for the after-treatment of Bifid Finger.

When the phalanx is not completely bifid it should be split down to its base with bone forceps and the desired half removed. After this has been done, the lateral ligaments on the opposite side of the joint will usually require division, so that the part of the phalanx left may be brought into line with the rest of the finger. This should be done from the interior of the joint, which will already have been opened in removing the other half of the phalanx. Any other structures that are tense and resist re-position must also be divided.

Immediately after the operation, a narrow splint may be applied to the opposite side of the finger to that on which the deflection is, and the phalanx drawn outwards towards it; when the wound has healed, however, it is best to fix the digit and the wrist in a silicate bandage, which interferes less with the movement of the rest of the hand than the wooden splint does. This casing may be split along one side and should be removed at first once a week, and finally every day, so that massage and passive movement may be practised; otherwise the joint may become very stiff. About six weeks after the operation the silicate case may be replaced by a metal splint, moulded to the wrist and forearm, and prolonged down along one side of the digit; the terminal phalanx is strapped to this so as to keep it in proper position (see Fig. 68).

WEBBED DIGITS.

This condition affects both toes and fingers, but in the former case it does not usually cause any inconvenience, and no treatment is necessary. The presence of a web between the fingers, however, is a great disadvantage; it is unsightly, it prevents the proper separation of the digits, and it thus interferes greatly with the usefulness of the hand; moreover, fingers so united do not develop as well as those which are free. In almost all cases, therefore, it is necessary to attempt to remedy the deformity.

The cases of webbed finger vary considerably, both as to the extent of the web in the downward direction and the closeness with which the fingers are bound together. In some cases (Fig. 69, *A*) there is merely a slight extension downwards of the natural web between the fingers, which may only reach as low as the first interphalangeal joint. This web is usually loose and does not inconvenience the patient, whose chief reason for seeking surgical advice is rather to have an unsightly deformity removed than to have the usefulness of the hand increased. In others, again, the web extends right down to the terminal phalanges, and these cases may be divided into three groups: (1) those in which the web is quite broad and allows considerable play to the fingers (Fig. 69, *B*); (2) those in which the fingers are bound closely together by a narrow web, but without any actual fusion of adjacent bones (Fig. 69, *C*); and (3) those in which the bones of the adjacent fingers are more or less completely welded together (Fig. 69, *D*).

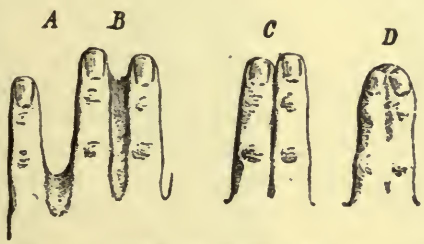


FIG. 69.—DIAGRAMS TO ILLUSTRATE THE DEGREES OF WEBBED FINGERS. *A* and *B* show two forms of the broad and extensile web; in *A* it is a slight prolongation of the normal web, while in *B* it reaches almost to the finger-tips. *C* shows the fingers bound together throughout their whole length so closely that there is practically no web between them. In *D* the bones of the adjacent fingers are fused together.

TREATMENT.—When the Web is Broad.—Many operations have been introduced for the separation of webbed fingers, but none of them is altogether satisfactory except for the cases in which the web is broad and extensile. The two chief difficulties in the operative treatment are, the constant tendency to the re-formation of the web after division, and the tendency to contraction of the finger or fingers (especially in the direction of flexion) after they have been separated.

If the web be simply divided down the centre, it will be found that the web re-forms as the wound heals, and no mechanical arrangement seems able to prevent this. Various methods have been employed in order to prevent this re-formation of the web; for this rapid healing at the cleft between the fingers is essential. The two following methods are employed with this end in view.

The Ear-ring Perforation.—In the perforation method the plan adopted is practically identical with that employed in perforating the ear for ear-rings (see Fig. 70). A hole is made through the base of the web and a piece of stout silver wire is inserted through it, bent loosely round one of the fingers into a ring, and kept in position until cicatrisation is complete. This requires some five or six weeks, at the end of which time a knife is introduced into the hole and the web split down to the free edge. If possible, the cut edges on each side of the cleft should be united by sutures so as to secure immediate union and avoid a granulating wound, which would undergo contraction. After this operation, even in favourable cases, considerable contraction may still take place.

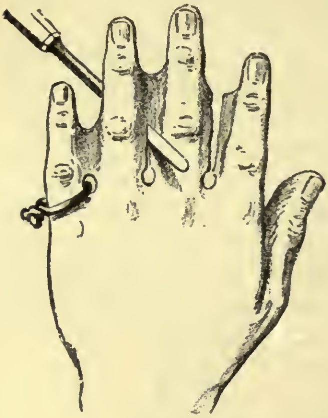


FIG. 70.—THE EAR-RING PERFORATION OPERATION FOR WEBBED FINGERS. Three stages of the operation are shown. On the left is the ring of silver wire *in situ*: in the centre the web is being divided after cicatrisation of the perforation, while on the right are seen the redundant edges ready to be trimmed off.

The V-shaped Flap.—A more satisfactory method is to turn a flap into the cleft after the web has been divided. The best way of doing this is to cut a triangular flap with its apex downwards from the dorsal surface of the base of the web (see Fig. 71). A triangular flap, the apex of which is in the centre of the web sufficiently low down to enable the flap to be folded into the cleft and stitched to the skin of the palm, is marked out by carrying an incision upwards on each side from this point to one a little to the side of the corresponding phalanx and opposite the base of the web. This flap, consisting of skin and fat, is dissected up, and then the web is split down the centre. The flap is now folded down between the fingers, its apex is stitched to the palmar edge of the cleft, and its sides to the adjacent skin edges. The result is that immediate union takes place and no contraction occurs. The raw surface on each finger left by splitting the web is then trimmed, and the edges stitched accurately together so as to obtain union by first intention. The granular fat often projects between the edges of the skin and prevents accurate apposition; when this is the case, it should be clipped away before the sutures are inserted. If a small space be left near the cleft where the edges will not come together, it is well to place a skin-graft over the raw surface. This operation is useful for partial and complete webs, and is the best that can be adopted, provided that there is plenty of room between the fingers.

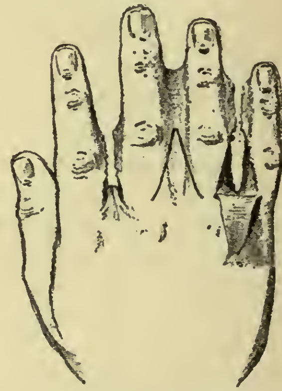


FIG. 71.—THE V-SHAPED FLAP OPERATION FOR WEBBED FINGERS. The three stages of the operation are here shown. In the centre the flap has been marked out; on the right it has been dissected up, while on the left it has been turned down and sutured into the cleft.

When the Web is Narrow.—This is a much more difficult condition to treat successfully. Under these circumstances the operation just described is unsuitable, for although healing might be obtained at the cleft, a large raw surface would be left along the side of each finger, which would contract and lead to lateral bending and flexion of the fingers if it were allowed to heal by granulation; the patient would finally have the fingers flexed and bent to one side, with a rigid scar running along the flexor aspect of the finger on that side. This contraction may

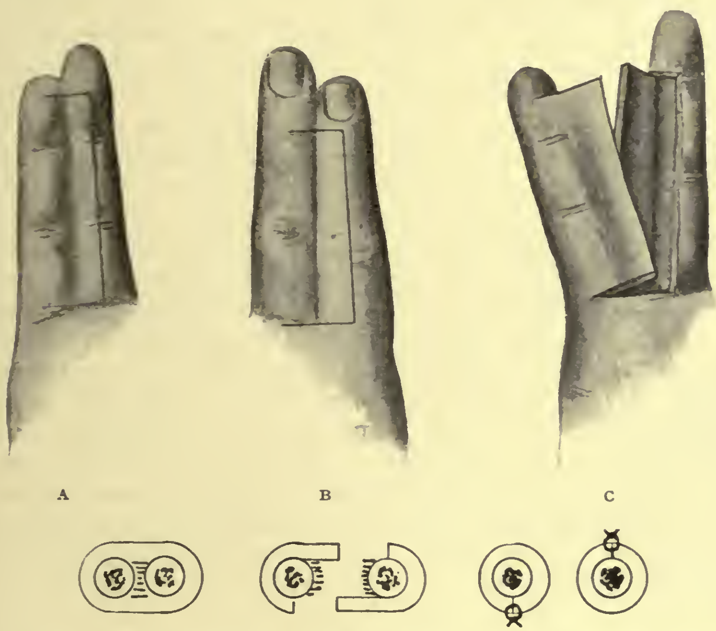


FIG. 72.—DIDOT'S OPERATION FOR WEBBED FINGERS. A and B in the upper row show the incisions. C shows the fingers separated. In the lower row are diagrammatic cross-sections of two adjacent fingers before, during, and after operation.

be prevented to some extent by immediate skin-grafting (see p. 52), a single long graft being applied to the raw surface on each side, and the fingers being bound together and left undisturbed for ten days. The result of skin-grafting in these cases, however, is not generally satisfactory, as contraction often occurs in spite of it. Simple splitting and skin-grafting is therefore not to be recommended.

Didot's Operation.—The operation most commonly adopted for this particular form of the deformity is that known as Didot's (see Fig. 72). It is performed as follows: two incisions are made, one along the middle of the dorsal suiface of one finger, and another along the middle of the palmar surface of the other, from a point opposite the free end of the web as far up as the knuckle. At each end of these two vertical incisions a transverse one is carried across to the adjacent border of the other finger, and thus two flaps are marked out, which are carefully dissected up to the interval between the bones. When this point is reached, the soft structures are split between the bones, and there is then a flap attached to each of the separated fingers, formed by the skin of the front or back of the corresponding fingers respectively; the base of these flaps is on the palmar surface of one finger, and on the dorsal of the other. Each flap is then wrapped round the side of the finger to which it belongs and is stitched in place, the one along the back, the other along the front. The flaps, however, are seldom broad enough to meet the line of incision in front or behind, and generally an interval, sometimes a considerable one, is left between the edge of the flap and the edge of the skin to which it should be stitched. In these intervals the fat protrudes, and ultimately a narrow line of granulation-tissue forms; this contracts, and may give rise to considerable deformity. In order to obtain rapid healing, Thiersch's skin-grafts (see p. 52) should be laid on this narrow line at the time of the operation; but in this operation, as in the previous one, the grafts do not prevent the occurrence of a certain amount of contraction. The final outcome of the operation is generally that the result is good in one finger, while in the other it is poor. The one that has the palmar flap is usually satisfactory, as the narrow scar which forms along the dorsum does not interfere with movement; the patient can always flex the finger, and thus undue contraction is prevented. On the other hand, the finger which has the dorsal flap, and in which the cicatrix lies along the palmar surface, generally becomes contracted, the narrow scar causing flexion of the finger, and consequently an imperfect result. This tendency of the finger which has the dorsal flap to become contracted must be borne in mind, and skin-grafting should always be employed over any portion that is left raw, and, besides this, a splint must be worn for a long time, so as to keep the finger extended. The splint (see Fig. 73) should be applied to the dorsal surface, taking purchase from the lower part of the forearm and back of the hand; opposite the knuckles a prolongation extends along the back of the finger, and to this the latter is strapped. The splint should be worn day and night, being only left off at intervals to permit of passive movement; at the end of two months it may be left off during the day, but should be worn at night for at least six months,

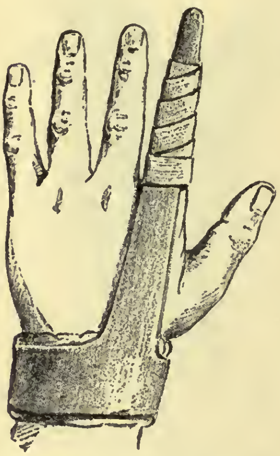


Fig. 73.—Splint for use after Didot's Operation. The splint is made of well-padded metal, and the finger prolongation can be bent back to any desired extent so as to counteract all tendency to flexion.

and generally for a year. There is a strong tendency to the formation of a cicatricial ridge along the palmar surface of one finger, and consequent contraction, in spite of the splint.

When several fingers are united, it is well to separate only two at a time, and to allow some weeks, or even months, to elapse before proceeding to separate a second pair. There is a distinct advantage in doing the operation at an early age, because the webbing of the fingers undoubtedly interferes with their growth; a finger that has been freed grows faster than one that is still webbed. At the same time, the hand in infants is so small and so difficult to fix that it will generally be found best to wait until the child is a year or two old and the fingers have attained a length and size more suited for the application of splints.

When the Bones are United.—When there is bony union between the adjacent phalanges, treatment is much more difficult and sometimes it is doubtful whether it is advisable to interfere with them at all. When the deformity is marked, and the finger is not so useful as it might be were the deformity overcome, an attempt may be made to remedy it. The only proceeding that offers any prospect of success, however, is to remove a portion of the welded bones so as to obtain one good finger instead of two bad ones; if any attempt were made to separate the fingers, there would not be sufficient covering for the two raw surfaces. When, however, one bone has been dissected out, the skin covering the portion of the finger taken away will be sufficient to cover the raw surface left, and there may be less deformity and greater mobility. The precise steps to be adopted in operating must, however, depend on the condition present, and cannot be described here.

HAMMER TOE.

By the term 'hammer toe' is understood a deformity of which the essential element is flexion of the first interphalangeal joint of the toe; there is also generally a secondary hyper-extension of the first phalanx on the metacarpal bone. The terminal phalanx usually retains its normal position, but in bad cases it may be in the same straight line with the second, so that the last two phalanges have their long axes directed vertically downwards, and the tip of the toe comes into contact with the ground. The terminal joint may be hyper-extended, however, the result being that the toe resembles the letter **Z** (see Fig. 74). The deformity usually affects the second toe, but it may affect others.

Hammer toe may be congenital, and is then often hereditary; in these cases it is not usually marked until the patient begins to walk. It may also be acquired, and the chief cause is the presence of the condition known as hallux valgus; the great toe is adducted, overrides and causes flexion of the second phalanx of the second toe, and the typical deformity just mentioned.

The condition is sometimes very troublesome on account of the development of corns upon the points exposed to pressure; when there

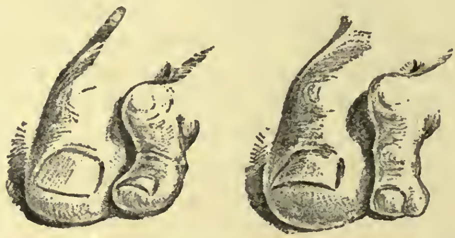


FIG. 74.—HAMMER TOE. The figure illustrates the two varieties of the affection. On the left-hand side is the Z-shaped deformity, in which there is, besides hyper-extension at the metatarso-phalangeal joint, flexion at the first and hyper-extension at the second interphalangeal articulation. In the other figure the deformity is similar, except that the terminal phalanx, instead of being hyper-extended upon the second, is in the same straight line with it.

are no corns it gives rise to no trouble whatever. There is generally a large and tender corn over the first interphalangeal joint where it rubs against the boot, and also on the free end of the toe, especially when the terminal phalanx looks straight downwards; the corn is then often situated just behind the free edge of the nail, which is somewhat recurved, and it causes intense pain when the patient walks. Corns also form on the inner aspect of the toe where the great toe comes into contact with it.

PATHOLOGICAL CHANGES.—The ligaments of the first interphalangeal joint, in particular the lateral and the plantar or glenoid ligaments, are markedly shortened when the deformity is once established.

FIG. 75.—DIAGRAM TO SHOW HOW FORCIBLE STRAIGHTENING OF A HAMMER TOE MAY RESULT IN DISLOCATION. The lateral ligaments, which are shown in the figure, are attached on each bone at a point somewhat below the centre of the lateral aspect. Any attempt at forcible straightening while the ligaments are intact must therefore either fail or result in dislocation of the base of the second phalanx beneath the head of the first, as shown in the right-hand figure.

This is accompanied by secondary contraction of the flexors of the toes (which, however, does not occur until a late period) and by alterations in the articular surfaces. In bad cases the second phalanx is actually drawn up under the first, leaving the articular surface of the latter entirely uncovered. Hence, attempts made to straighten the joint forcibly, even after tenotomy of the flexor tendons, result in a dislocation of the second phalanx beneath the first (see Fig. 75). The articular cartilage over the head of the first phalanx rapidly becomes converted into fibrous tissue, so that an imperfect joint must result, even if the joint surfaces be restored to their relative position.

TREATMENT.—The treatment of this deformity is somewhat troublesome; it may be carried out in three ways: (1) by means of mechanical appliances designed to prevent or overcome the flexion of the second phalanx; in acquired cases this should be combined with treatment directed to the cure of the co-existing hallux valgus and also with division of the contracted ligaments or other structures around the joint; (2) by removal of the head of the first phalanx so as to allow the phalanges to be brought straight; and (3) by amputation.

Appliances.—In the less advanced cases it is best to commence by dividing the lateral and glenoid ligaments of the first interphalangeal joint and (in the rarer cases calling for it) the flexor tendon before employing mechanical appliances; a tenotome with a very small cutting blade should be used for the purpose. The line of the joint is defined by the finger-nail, and the point of the knife made to penetrate the skin at right-angles to the long axis of the toe at the junction of its dorsal and lateral aspects, and is pushed directly down into the joint, the lateral ligament to be divided being rendered tense by lateral pressure on the point of the toe. Slight movement of the knife generally divides the ligament immediately, when the process is repeated on the opposite side. The toe is then forcibly straightened and is secured to an apparatus designed to prevent recurrence of the flexion. A convenient form is a T-shaped splint (see Fig. 76), the horizontal limb passing transversely beneath the sole about the level of the tarso-metatarsal articulations, and being secured there by means of a strap or band, while the vertical part extends underneath the toe as far as its tip; the splint should be well padded, and the toe strapped down to it. The treatment of the co-existing hallux valgus (see p. 281) should never be neglected, as it is most important to prevent the pressure of the first toe on the second. No permanent good is likely to accrue if the hammer toe be straightened and the hallux valgus left untreated.

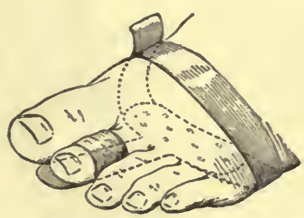


FIG. 76.—T-SHAPED SPLINT FOR HAMMER TOE. A greater amount of pressure over the first interphalangeal joint may be obtained if necessary by inserting a pad of lint or wool between the tip of the toe and the splint.

This procedure is only of use in the milder forms; in the more severe ones, particularly those that are congenital in origin, the toe will not come straight even after division of the ligaments and tendons, for the skin and the other soft structures are permanently shortened, and forcible attempts to straighten the joint result in dislocating the base of the second phalanx below the head of the first. In severe cases also the articular surfaces are so much altered that an imperfect result would be obtained even if they were brought properly into contact.

When there is flexion of all the toes, as may be the case in pes cavus, a special splint with bands passing over the dorsal surface of each toe will be required (see Fig. 77). Later on, when the tendency to flexion has been greatly reduced, an efficient splint may be made by attaching a stout glove-finger of suitable size to a piece of whalebone or flexible steel covered with chamois leather; this lies on the dorsum of the foot

Fig. 77.—Splint for all the Toes. This is used when there is contraction of several toes.

Fig. 78.—Splint for use in After-Treatment of Hammer Toe. This is one that can be easily improvised, and is suitable for use where it is merely desired to prevent the recurrence of flexion. It is made of whalebone or light flexible steel, which can be bent to fit the outline of the foot. If preferred, it can be made to lie along the sole of the foot.

beneath the stocking, and is fastened by a broad tape round the instep. The toe goes into the glove-finger (see Fig. 78).

Since some form of splint must be worn for a long time and may be required permanently, it becomes a question whether it is worth the patient's while to submit to this method of treatment. We are of opinion that in all except the slightest cases it is best to practise some form of operation which obviates the necessity of using a splint, and which gives satisfactory results without laying the patient up for any length of time.

Excision of the Head of the First Phalanx.—The operative procedures which may be adopted are removal of the head of the first phalanx, excision of the joint, or amputation. The third method is not to be recommended; removal of the toe, in acquired cases, simply favours the increase of the hallux valgus; an exception may be made in the case of working men, who wish to get to work as quickly as possible, and who therefore insist on amputation. We strongly advise the removal of the head of the first phalanx in all but the slightest cases. If enough bone be removed, the toe can be straightened without any tension, and there is no need to divide ligaments or tendons in the first instance. This gives the patient a movable joint which has little tendency to become flexed again ; the result is much better than that of excision of both the articular surfaces.

The operation is done as follows. An incision is made along the dorsal surface of the toe parallel to and a little to one side of the extensor tendon ; it should commence an inch above the first interphalangeal joint and run down well beyond it. The incision is carried directly down to the bone, and the soft structures are separated from the end of the first phalanx by a periosteum detacher and a few strokes of the knife. The lateral ligaments are then divided and the head of the bone is made to project into the wound and is nipped off by cutting pliers. The bone is generally divided about a quarter of an inch above the articular surface, but enough must be removed to allow the toe to be brought straight without any tension. After the bleeding has been arrested, the corn over the first interphalangeal joint is excised, the wound united by fine sutures, and a gauze dressing applied. The plantar splint referred to above (see p. 277) is then applied, with an extra amount of padding beneath the tip of the toe, to ensure the latter being kept straight when the bandage is applied. When hallux valgus is present, suitable treatment for that condition (see p. 281) must be adopted simultaneously. When the wound has healed, the toe and the front part of the foot should be put up in a silicate bandage, and the patient allowed to walk. The bandage can be dispensed with in about seven weeks and the patient regarded as well.

After-treatment.—Special attention must be paid to the boots, which should not be too short, as otherwise the end of the toe will be pressed upon and flexion will recur. As there will often be hallux valgus co-existing, the remarks made with reference to boots for hallux valgus (see p. 281) apply here also. The socks should be furnished with a separate compartment for the great toe.

HALLUX VALGUS AND BUNION.

By the term Hallux Valgus is understood a condition in which there is adduction of the great toe. As a consequence of this adduction, the inner side of the head of the first metatarsal bone becomes unduly exposed and consequently is subjected to direct pressure against the boot ; inflammation therefore takes place in the exposed bone and the periosteum over it, and considerable thickening of these structures occurs. A bursa is subsequently developed in the subcutaneous tissues over the enlarged bone, a condition commonly known as a bunion ; by an inflamed bunion is meant one in which the bursa has become inflamed. The inflammatory attacks may pass off, leaving additional thickening of the surrounding structures, or they may go on to suppuration, which may be followed by extensive cellulitis of the foot, perforation of the metatarso-phalangeal joint of the great toe, septic arthritis. necrosis, etc. Moreover, as time goes on, these joints frequently undergo the changes characteristic of osteo-arthritis.

In hallux valgus the great toe may be deflected so as to lie under or over the second; in the latter case (which is the usual one) the toe is also rotated so that its upper surface looks somewhat inwards, and its

FIG. 79.—DIAGRAM ILLUSTRATING THE PRINCIPLES TO BE OBSERVED IN MAKING BOOTS. *C* shows the deflection of the great toe and the cramped position of the others entailed by wearing the ordinary pointed-toed boots; it will be seen that the point of the boot is opposite to the middle line of the sole. *B* shows the outline of the sole of a boot constructed on sound anatomical principles. The inner border of the front part of the sole is nearly parallel to the long axis of the foot, the boot comes to a point opposite the great toe, and is sloped away from that point to the outer border in accordance with the length of the other toes, which are thus not cramped at all. *A*, a very usual form of so-called anatomical boot which, while it is free from the most flagrant faults of the usual pointed-toed variety, is not so good as *B*. The inner border of the sole is not quite straight, and so tends to deflect the great toe somewhat, while the squareness of the end of the boot both leaves a lot of unnecessary space between it and the toes and detracts considerably from the appearance of the foot. (After *Meyer*.)

inner border is directed towards the sole. Thus there is adduction of the toe combined with rotation, and it is important to bear this compound deformity in mind when attempting to remedy the condition.

The affection is essentially produced by ill-fitting boots, those in which the toe of the boot comes to a sharp point opposite the middle line of the foot being the chief offenders. A boot pointed in this way crowds the toes together, and if it must be brought to a point, the latter should be towards the inner side of the foot so as not to deflect the great toe from its normal line (see Fig. 80).

Bunion is especially marked in those who suffer from gout or rheumatoid arthritis; it is probable that one of these conditions is necessary for the full development of the trouble.

Cases of hallux valgus may come under observation: (1) at an early stage, when the divergence of the toe and the enlargement of the end of the bone are comparatively slight; (2) when the condition is well developed, with considerable enlargement of the bone and the formation of a bursa over it; and (3) when the bursa has suppurated and a sinus is left.

FIG. 80.—DIAGRAM SHOWING THE RELATIONSHIP OF THE IMPRESSION OF THE FOOT TO THE LINES WHICH BOUND ITS OUTLINE.—*A* is a normal foot. *B*, a mild degree of hallux valgus. The outline in *A* with the corners rounded off, represents the proper outline for a boot. *B* similarly treated illustrates the faulty shape of boots made with the point in the centre. (*Modified from Whitman.*)

TREATMENT. — **In the early stage** much may be done to render the patient comfortable and to prevent further development of the deformity by the use of properly constructed *boots* combined with some mechanical arrangement designed to counteract the adduction of the great toe. The boots must be long enough, not too narrow, and the inner border of the sole, as far as the extremity of the great toe, must be almost straight. The most suitable boots, on the whole, are those in which the inner border is straight and passes well beyond the tip of the great toe, and of which the outer border is rounded to correspond to the curve of the other toes (see Fig. 79). They cannot be said to be comely, but nevertheless they must be worn in these cases.

In addition, means must be employed to press the toe into position and to overcome the adduction. In quite early cases a pad of lint may be worn between the first and second toes, but it is apt to press injuriously on the other toes, and does not always attain the desired end. A better plan is to have the socks made with a separate compartment for the great toe (the so-called '*digitated socks*'), to see that a suitable boot is worn, and to have the toe frequently manipulated so as to bring it into a straight line with the inner border of the foot. In most cases, however, it is advisable, for a time at least, to employ some form of apparatus to keep the toe in its proper position; a common one is what is known as a '*toe-post*,' made by fastening a vertical piece of stout leather to the sole of the boot in the interval between the great and the second toes (Fig. 81). The great toe is first brought straight by introducing a small roll of flannel between it and the second toe. The boot is then put on and the great toe slips into its proper position, the narrow flannel roll between the two toes being removed by pulling upon a string fastened to one end; the flannel uncoils and is withdrawn. A digitated sock must be worn if a toe-post is used. The plan answers well for the slighter cases, but when the deflection is great and the trouble is of long standing, considerable friction is caused by the pressure of the great toe against the post, and pain and sometimes ulceration results, so that the patient is unable to continue it. Under these circumstances a

FIG. 81.—DIAGRAM TO ILLUSTRATE THE EMPLOYMENT OF A 'TOE-POST.' The 'toe-post' is seen in the cleft between the great toe and the second. It is made of stout leather or wood, and is fixed to the sole of the boot, which should be of the shape shown in the figure. The great toe is thus confined in a compartment from which it cannot escape, and no lateral deflection is permitted.

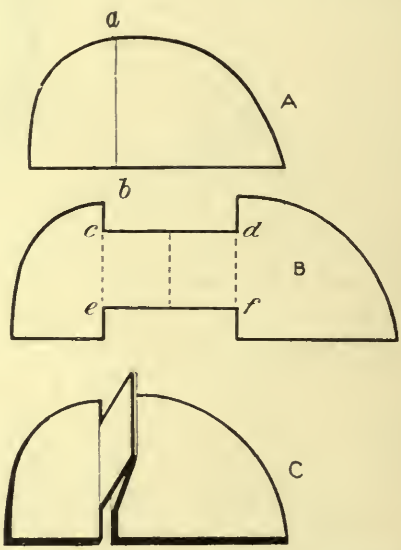


FIG. 82.—A METHOD OF IMPROVISING A TOE-POST. A piece of paper is cut to the shape shown in A corresponding to the outline of the anterior part of the foot. This is divided into two along the line *ab*. These pieces are laid on a second piece of paper so that the distance between them is equal to twice the depth of the foot, measured between the great and second toe. The two lines *cd* and *ef* are now drawn, and a paper pattern made as shown in B. This is cut out in block tin which is folded along lines corresponding to the dotted lines in B, so as to produce the appearance shown in C. This is put into the boot and forms a toe-post.

special form of *splint* must be employed. A great variety of these have been introduced; a fairly satisfactory one is here figured (see Fig. 83); it is applicable to cases of medium severity in which there is no marked rigidity. It consists of a metal spring running along the inner border of the foot and curving outwards beneath the ball of the great toe. The spring runs nearly to the tip of the great toe, and to its extremity is attached a band which passes around the point of the toe, the other extremity of the apparatus being fastened to the ankle by an elastic band. Opposite the arch of the instep the spring articulates, by means of a movable joint, with a small vertical plate, which takes purchase from the instep and acts as a fulcrum. An elastic band runs from the posterior end of the splint over the outer side of the foot, around the ankle, and down over the inner side, where it is fastened to a hook on the vertical piece or fulcrum. The effect of this is to draw the posterior end of the splint outwards towards the heel, whereby the front portion, and with it the great toe, is carried inwards, and the faulty position rectified. The apparatus will go inside a boot of fair size, and most patients can wear it and walk without marked inconvenience. Any apparatus for the correction of this deformity must be worn by night as well as by day, for if it be discarded at night, the toe tends to assume the faulty position again, and the cure is retarded. Should there be any tenderness of the joint or inflammation of the bursa over it in these milder cases, the application of lead or lead and opium lotion, with the foot in the elevated position, usually reduces it rapidly.

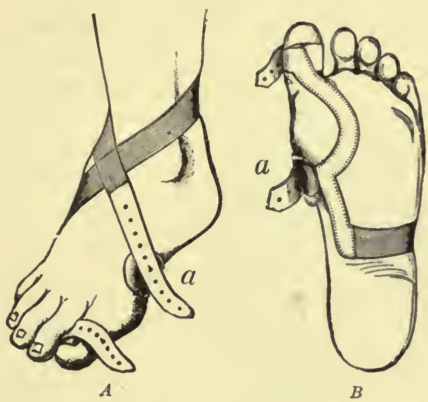


FIG. 83.—BUNION SPRING. The spring is applied to the foot as shown in *A* and the great toe secured to it. The fulcrum of the lever *a* rests immediately behind the enlarged head of the metatarsal. The band at the posterior end of the spring is then carried outwards across the sole at right angles, across the front of the instep, round behind the ankle and downwards again across the front of the instep to the inner border of the foot, where it is attached to the fulcrum *a*; this is shown in *B*. Sufficient traction must be exerted on the band to pull the toe into position; if this cause pain, as much traction must be employed as can be borne with comfort, and this can be gradually increased. The boots in which these springs are worn should have specially stout soles so as to avoid all risk of breakage. (*Krohne* and *Sesemann*.)

When the deformity is more severe, and the patient suffers considerable pain, it is best to adopt operative measures at once, for apparatus is not likely to do much good and only acts as an additional impediment to locomotion; the permanent enlargement of the bone, which is the chief cause of the trouble, cannot be diminished by anything short of operation. In addition to this also, the bursa over the joint will probably have undergone a series of attacks of inflammation and its walls will be permanently thickened, so that palliative measures are not likely to give more than temporary relief.

Of the *operative procedures* employed for the cure of hallux valgus we prefer the following. After thorough disinfection of the part, an incision is made along the inner border of the dorsum of the toe, from just beyond the articular surface of the head of the metatarsal bone backwards to half an inch behind the point at which the enlargement of the bone ceases. The incision should be convex upwards, but its extremities should not be carried too far down towards the plantar surface for fear of subsequent pain in the scar (see Fig. 84). A flap is turned down so as to expose the whole of the enlarged end of the metatarsal, and the bursa is dissected out ; the periosteum should not be taken up with the flap. The thickened portion of the bone is removed by means of a chisel and hammer, the line of the incision being from behind forwards, and parallel to the long axis of the shaft of the metatarsal. The whole of the enlarged inner surface of the head of the metatarsal is removed, and with it generally a small portion of the articular surface. The margins of the cut bone surface are rounded off with a chisel or a gouge so as to leave them absolutely smooth and without any sharp edge; failure to adopt this precaution may lead to considerable pain afterwards, and possibly also recurrence of the trouble. The internal lateral ligament is necessarily detached from its insertion into the metatarsal bone. After removal of the bone, it is well to introduce a tenotomy knife into the joint and to divide the external lateral ligament and any other resistant structure, so as to remedy the adduction properly. In very bad cases it may be necessary to divide the long extensor tendon, but in the majority of cases this is not called for.

FIG. 84.—OPERATION FOR HALLUX VALGUS, SHOWING THE INCISION THROUGH THE SKIN.

After the ligaments have been divided, the toe is brought forcibly inwards, and the deformity somewhat over-corrected—that is to say, the great toe is brought into a position of slight abduction.[1] The rotation of the toe upon the metatarsal bone, to which reference has already been made (see p. 280), should also be carefully corrected ; it is generally necessary to divide the outer part of the dorsal ligament in order to do this. When the toe has been brought into the desired position, an attempt should be made to shorten the internal lateral ligament so that it may form an obstacle to recurrence of the deformity. It is not easy to do this accurately ; the best plan is to pass catgut sutures through the remains of the ligament, and fasten it to the periosteum behind the cut surface of the bone. The wound should be stitched up without a drainage-tube.

A straight splint should be applied along the inner border of the foot from the heel to beyond the toes; it should be padded especially thickly immediately behind the area of operation. When the posterior part of the splint has been fastened to the heel and the instep, a considerable lateral deflection of the toe can be obtained by drawing it towards the extremity of the splint by a separate bandage. The deformity will then be over-

[1] The terms 'adduction' and 'abduction' are used in relation to the middle line of the foot and not of the body.

corrected, the toe being in a position of slight abduction and fully extended. After ten days the dressings are removed, the stitches taken out, and the toe carefully moved by the surgeon himself, who takes care to keep it in proper position. Then the toe is held in a position of slight abduction and extension with the rotation corrected, and a narrow boric lint bandage is wound around it and carried up over the foot and instep, and bandages soaked in a solution of silicate of potash are applied outside this. It is well to re-apply the wooden splint for two or three days until the *silicate bandage* has set firmly, when the patient may be allowed to walk with the foot in a gout-shoe.

FIG. 85.—THE BONES OF THE GREAT TOE IN A CASE OF HALLUX VALGUS. The black line indicates the amount of bone that must be cut away.

The bandage should be kept on for six weeks, when the toe should retain its position fairly well. *Passive movements* should be carried out for two or three weeks after this so as to get rid of any adhesions that may have formed during healing; these rarely give rise to trouble, however. The patient should wear a sock with a separate compartment for the great toe, and also the spring apparatus for bunion (Fig. 83) for two or three months so as to keep the toe in its abducted position; sometimes the result is so good that a boot with a toe-post is all that is necessary. The boots must be constructed on the principles laid down on p. 281. In about three or four months after the operation the patient is generally able to discard all apparatus, and there is no fear of recurrence if proper boots be worn. The results of the operations are extremely satisfactory. It is important to remember, however, that the joint is necessarily opened, and that strict asepsis is therefore of primary importance.

Excision of the head of the first metatarsal has been employed for this affection and is strongly advocated by some. It should be borne in mind, however, that removal of the head of the first metatarsal impairs the walking power of the foot very considerably, and, in view of the satisfactory results obtained by the procedures already described, we are inclined to think that such an operation is only necessary when there are extensive alterations in the head of the metatarsal bone such as lipping and outgrowths. When this procedure is carried out, some of the soft tissues should be interposed between the divided ends of the bones in order to prevent osseous ankylosis from taking place.

The surgeon is sometimes called upon to treat a **bunion in which suppuration has occurred.** These cases should be treated first upon the general principles applying to suppurative bursitis (see Vol. II.). The cavity should be laid open freely and drained, and dressings suitable to the degree and character of the inflammation should be applied. It is out of the question to adopt the operative procedures just described for the radical cure of the bunion until the wound has been soundly healed for some weeks; its cure should then be undertaken upon the lines already laid down.

In some cases no true acute suppuration occurs, but a sinus forms, leading into the joint and discharging a serous or synovial fluid. In these cases there are usually extensive osteo-arthritic changes, and healing will not be obtained until the head of the metatarsal bone has been removed.

HALLUX FLEXUS—HALLUX RIGIDUS.

In hallux flexus the great toe is bent somewhat downwards towards the plantar surface; in hallux rigidus it is quite straight; in either case any attempt to extend it gives rise to considerable pain. The result is that the patient cannot walk with the foot in the normal position owing to the necessity of avoiding movement of the toe; generally he walks upon the inner border of the foot, which is kept in the abducted position. The deformity is associated with flat foot, and in many cases appears to be the direct result of it.

Hallux rigidus is described as existing alone. Undoubtedly cases are met with in which the great toe is painful and stiff but not flexed; flexion will invariably develop later, however, if the affection be left untreated. We shall therefore describe the treatment of the two affections together.

TREATMENT.—In the early stages a *Whitman's spring*, combined with the *exercises* recommended for flat foot (see p. 303), will often cause the patient to lose his pain rapidly; the stiffness of the joint then disappears, and locomotion is no longer painful. In the more severe cases, however, it may be necessary to combine *division of the lateral ligaments* of the joint, and possibly also of the plantar fascia, with the treatment of the flat foot.

Marked alterations take place in the joint and the ligaments in the more severe cases, however, so that no real improvement is effected in the toe, although the flat foot may be remedied. These cases therefore call for some *radical operation* which may take the form of removal of the base of the first phalanx or the head of the metatarsal bone, the aim of the operation being to allow the joint to be brought straight by removing one of the articular surfaces which enter into it. The operation usually done is removal of the head of the metatarsal; the great objection to it is, however, that this structure plays a most important part in proper progression, and its removal is likely to interfere seriously with the usefulness of the foot. In bad cases, however, it may have to be done.

A perfectly good result, however, can be obtained in the less severe cases that nevertheless call for operative interference, by removing the base of the first phalanx. The operation is done through an incision about an inch in length, parallel and a little internal to the inner border of the extensor tendon. The periosteum is detached from the first phalanx by a suitable rugine, and the base of the bone is then nipped off with a strong pair of cutting pliers. This allows the toe to be brought straight without any tension. The periosteum and any adjacent soft tissues are then turned in so as to cover the raw bony surface and thus to prevent the occurrence of ankylosis.

The wound is closed without a drainage-tube, and the toe fixed to a plantar splint so padded that the toe is a little hyper-extended. When the wound has healed, the toe and front part of the foot should be put up in a *silicate bandage*, applied while the arch of the foot is restored as much as possible by bending the metatarsal bones downwards; this leads to an improvement in the flat foot, whilst the parts are being kept at rest for proper consolidation to occur. After about six weeks the patient may be provided with a Whitman's spring (see Fig. 91), and allowed to walk. The results are usually good; locomotion is perfectly satisfactory and quite painless.

ANTERIOR METATARSALGIA, OR MORTON'S NEURALGIA.

This important condition was first fully described by Morton, of Philadelphia, after whom it is named. It is a painful affection of the anterior part of the foot, usually in the neighbourhood of the heads of the third and fourth metatarsal bones. The pain is neuralgic in character and is referred to the plantar aspect; it may be so severe that the patient is unable to walk or bear any pressure upon the affected region. It is generally impossible for the patient to wear narrow shoes, and in some cases boots or shoes of any kind cannot be tolerated. It is usually noticed that the pain diminishes or ceases entirely as soon as the shoes are taken off and the foot is elevated.

Callosities may form upon the sole beneath the head of the fourth metatarsal; sometimes they also form beneath the head of the third, or even the second, and then, to avoid pain, the patient bears his weight upon the inner border of the foot, and avoids putting any pressure upon the outer side at all. These callosities, besides adding considerably to the pain, are liable to attacks of inflammation, which cripple the patient still further. If the foot be looked at from the dorsal surface, when the toes are flexed towards the sole, the heads of the metatarsal bones in the neighbourhood of which the pain is most marked are seen to be on a lower level than the rest. This is apparently due to relaxation of the ligaments that bind the heads of the metatarsal bones together. The pain is supposed by Morton to be due to a lateral compression of the foot, which causes the head of the fifth metatarsal to compress branches of the external plantar nerve against the head of the fourth. Although this explanation may be the correct one in some cases, in others the pain is probably due to the undue pressure exerted upon the sole by the head of the bone which has become displaced downwards, from its normal position.

The affection not infrequently follows upon injury, but cases undoubtedly occur in which there is no history of any injury, and these are generally the ones in which narrow boots are worn and bring about lateral compression of the metatarsal bones. The condition is often associated with flat foot, and sometimes the whole trouble disappears when the depression of the arch is corrected, It occurs more frequently in women than in men.

TREATMENT.—This may be divided into palliative and operative, the majority of cases yielding to the former.

Palliative Treatment.—The first essential is that the patient should wear *properly fitting boots.* They should be sufficiently wide and should everywhere afford proper support to the foot. They should be made to a plaster cast of the foot, as it is otherwise difficult to combine proper support with avoidance of undue pressure. In addition, a *Whitman's spring* (see p. 303) should be worn to support the arch of the instep, and the *tiptoe exercises* recommended for flat foot (see p. 302) may with advantage be prescribed so as to strengthen the structures in the sole. *Massage* is of value, and douching the foot is also useful. An anodyne application such as belladonna, to the sole of the foot, may be called for to relieve pain. The majority of the early cases treated in this manner yield satisfactory results.

Operative Treatment.—In bad cases, however, in which the affection has lasted a long time, no permanent benefit results from any of these procedures, and it is necessary to have recourse to operative interference. The procedure which has yielded the best results up to the present time is *removal of the head of the metatarsal bone* which is unduly depressed ; in most cases this is the fourth, but sometimes it is necessary to remove the head of the third as well. The operation is performed by making a longitudinal incision upon the dorsal aspect of the foot over the head of the affected metatarsal bone, parallel to but on one side of the extensor tendon. The edges of the incision are retracted, the tendon is hooked aside, and the soft parts are separated from the head of the bone with a periosteum detacher. The neck of the metatarsal is then divided by cutting pliers or a fine saw, and the head is removed after division of the ligaments attaching it to the neighbouring bones. The patient should lie up for about three weeks after the operation. After the operation he must wear properly constructed boots made to a plaster cast of the foot. Should flat foot be present, he should also be fitted with an artificial support to the instep.

CONTRACTIONS OF THE FINGERS.

The majority of contractions met with in the fingers are acquired. There is a congenital condition in which the little finger is flexed, and is in a position similar to that assumed by a hammer toe. The finger is flexed at the first interphalangeal joint, whilst the second and third phalanges are in the same straight line, or the terminal phalangeal joint may be hyper-extended.

TREATMENT.—In slight cases the deformity passes practically unnoticed, and does not call for treatment. When, however, the deformity is extreme, or when it is necessary to remedy it in order to enable the patient to carry out some particular form of manual labour, and especially when the right hand is affected, the treatment should be conducted on lines practically identical with that recommended for hammer toe (see p. 277). In the slighter cases, *division of the anterior and lateral ligaments* may be performed, and the finger afterwards kept on a splint both night and day for four to six weeks; it may then be left off during the day, and a narrow posterior splint applied during the night. The results, however, are generally very unsatisfactory; the deformity is congenital, and unless treatment be commenced at an early age, the joint surfaces are so altered that restoration of function is rarely perfect, and it is a question whether it is worth the patient's while to go through a prolonged course of treatment by splints when there is a great chance of the deformity recurring.

The simplest plan in these cases is to perform an operation similar to that employed for the cure of hammer toe—namely, the *removal of the head of the first phalanx*. This is easily done through a vertical incision upon the inner side of the little finger exposing the neck of the bone, which is divided by cutting pliers, and the head removed. The wound is stitched up, the finger brought straight and kept upon a splint for six weeks, when passive movement is begun and the splint discarded.

DUPUYTREN'S CONTRACTION.

This affection is primarily due to a contraction of the digital processes of the palmar fascia, the main body of that structure usually being only affected secondarily. In typical cases the affection runs an extremely slow course. It is generally symmetrical and usually first affects the ring finger on each side; the little finger is next affected, and in bad cases the remaining fingers may become attacked one after another, but in any case the ring finger is the most markedly contracted. The condition is more frequently met with in men than in women, and generally attacks those over fifty years of age. It is not uncommonly associated with gout, rheumatism, or osteo-arthritis. In some cases it is said to be hereditary, but whether it is that the tendency to this particular deformity is hereditary, or whether it is due to the associated hereditary gouty condition, it is hard to say. It is a noteworthy fact that the contraction is particularly prone to occur in persons, such as carpenters and the like, whose occupations necessitate considerable and repeated pressure by tools and instruments against the palm of the hand.

PATHOLOGY.—The essential alteration is thickening and shortening of the palmar fascia and the various processes of fibrous tissue given off by it. These changes are mainly confined to the digital processes, in the early stages at any rate, and the result of their shortening is flexion of the finger at the metacarpo-phalangeal joint. As the contraction becomes more marked there is flexion of the first interphalangeal joint as well; the second generally remains unaffected, the two terminal phalanges being nearly in the same straight line. Still later in the disease, the thickening affects the body of the palmar fascia, which then shows irregular masses of fibrous tissue upon it. The thickening also affects the small fibrous bands which pass from the surface of the fascia to the skin, and the result is that the skin becomes bound down to the palmar fascia and much puckered, so that there are often hard horny ridges and irregular thickenings in the palm, which are due to the thickened fibrous slips with the adherent skin over them. It is important to bear this point in mind when treating the condition. There is no primary contraction of the flexor tendons, and it is almost invariably found that the tendons offer no bar to the re-position of the finger after all the fascial structures have been divided. When, however, the affection has lasted for a long time there is secondary contraction of the ligaments of the articulations that have been kept flexed, and these structures may require division before the fingers can be straightened.

TREATMENT.—Nothing but operative interference is likely to be successful. Attempts to prevent or overcome the deformity by stretching the fascia by splints, elastic traction, and the like, cause pain, irritate the fascia, and lead to a rapid increase in the contraction. At the same time operative treatment is not always so satisfactory in its results as could be wished, because there is a tendency to the reproduction of the deformity.

Fibrolysin is often employed for this condition, and good results have been reported. Its use is, however, not free from danger, especially in old people, and cases of fatal purpura have been reported. We have seen no decided benefit from it in any of our cases.

INDICATIONS.—The following are the points that would lead the surgeon to employ certain operations in particular cases. (1) When the fingers are not bent beyond a right-angle, subcutaneous division is usually as satisfactory a method as any other. (2) When there are only one or two tight bands, when the skin is not markedly puckered, and when the fingers are not greatly contracted, the best method is to remove the fascia by careful dissection—the second procedure described. (3) In very advanced cases, in which the fingers are tightly flexed into the palm, this latter operation cannot be performed, because it is impossible to get proper access to the palm so as to make the requisite incisions. The best treatment then is to get the finger as straight as possible by means of subcutaneous division in the first instance. As a rule, however, this will not allow the finger to come quite straight because the skin itself is contracted, and therefore a further operation must be combined with subcutaneous division, so as to complete the straightening of the finger. The two operations, however, should be done at different times. Subcutaneous division endangers the vitality of the skin at various points, which, however, rarely sloughs, unless too great pressure be brought to bear on it; but if another operation were done immediately after it, the damaged portions of the skin would almost certainly die. Hence sufficient time must be allowed to elapse between the subcutaneous and the open operation to allow these damaged portions of skin to recover properly, and during this time the fingers should be kept somewhat extended on a splint; three weeks' interval is usually enough. The V operation is to be preferred in these cases. It is useless to attempt to dissect out the contracted fascia soon after subcutaneous division has been done, because all the tense bands have been divided, and they cannot be defined properly.

Subcutaneous division of the palmar fascia and the processes connected with it is the method most commonly employed, but it is not always the most satisfactory. Before performing this, or indeed any operation upon the palm, steps should be taken to soften the skin as much as possible for several days beforehand. The palm should be subjected to frequent soakings in hot water, washings with soft soda-soap, and kneadings with glycerine, vaseline, or lanoline. The operation itself must be carried out with scrupulous regard to antiseptic precautions (see p. 100). A tenotomy knife with a very small cutting blade is cautiously insinuated flatwise between the skin and the fascia; the cutting edge is then turned towards the fascia, and the contracted bands (which are rendered tense by traction upon the finger) are divided one after the other. As a rule a good many punctures are required, and the fascia must be nicked in all directions. The principal seat of division will be in the digital processes, so that the punctures are generally made between the transverse crease of the palm and the line of the first interphalangeal joint. When there is also puckering of the skin, the knife should be swept flatwise between the skin and the fascia so as to free the adherent portions. The operation should be carried out with the greatest thoroughness, and half to three-quarters of an hour may be consumed in a systematic endeavour to find and divide all the tight bands of fascia present. It is useless to attempt to cure the affection by simply dividing the fascia in one or two spots.

After all the tense fascial bands have been divided, the finger is extended fully and the palm kneaded, so as to rupture any fibres that may have escaped division. In doing this it is often found necessary to re-introduce the tenotomy knife and divide some tight band that had not been noticed previously. A pad of antiseptic gauze is then placed in the palm, and the hand put upon a palmar splint (see Fig. 86) which is padded especially thickly beneath the fingers, so as to produce good extension when the hand is bandaged to it. When the contraction is

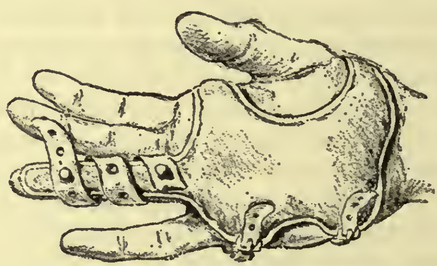


Fig. 86.—Dupuytren's Contraction. Splint for use immediately after Subcutaneous Division of the Fascia. This is made of light metal well padded, and can be bent somewhat should it be difficult to get the finger straight immediately after the operation; it can then be straightened gradually as the finger stretches. (After *Adams.*)

great and the skin is much thickened, however, the fingers must not be stretched unduly, partly because considerable pain would be caused, and partly because the skin might slough, since its vitality has been interfered with by the operation. In these cases, therefore, it is better to leave the fingers somewhat flexed for the first twenty-four or forty-eight hours, and then to increase the extension gradually by readjusting the splint and increasing the padding, or by fastening the metacarpals to the splint by an elastic bandage, which will gradually press the palm down flat upon the splint, the fingers being separated from it by the padding. In a week or so the fingers should have become rather over-extended.

For the first month the splint must be worn night and day; then a dorsal splint may be substituted for it, taking its purchase from the lower part of the forearm, and fastened round the latter with suitable straps. The splint should extend over the inner side of the dorsum of the hand as far down as the knuckles, and from this main piece separate prolongations arise, one for each of the affected fingers. These prolongations are bent somewhat backwards from the main portion of the splint, so that when the affected fingers are fastened to them by means of elastic bands they are in a position of slight hyper-extension (see Fig. 87); the thumb and any fingers unaffected are left free, so that the patient can use the hand to a certain extent. The splint should be worn night and day for at least six weeks, but it should be taken off two or three times daily so as to allow the fingers to be exercised, and massage and passive movement to the palm and finger to be practised; at the end of six weeks it may be worn only at night. The use of the splint at night should not be given up for at least six months after the operation; at the end of that time it can generally be abandoned entirely. When there is much stiffness of the joints and considerable rigidity of the skin, with hard horny thickenings, a course of treatment by superheated air is useful in getting the part supple; the fingers should be repeatedly moved and the palm kneaded with glycerine or lanoline so as to soften the skin.

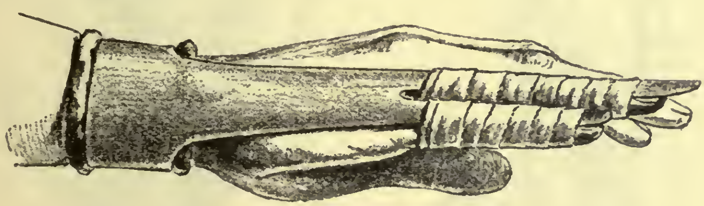


FIG. 87.—DUPUYTREN'S CONTRACTION. SPLINT FOR MAINTAINING FULL EXTENSION AFTER SUBCUTANEOUS DIVISION OF THE FASCIA. This splint is applied on the dorsal surface of the hand, and takes purchase from the wrist. Hence powerful extension of the fingers can be got. The finger prolongations (which will vary in number according to the fingers affected) can be bent backwards if necessary, as the splint is made of malleable metal.

The usual result of subcutaneous division of the fascia carried out in this thorough manner is that the patient remains well for three or four years, and then the contraction recurs and a second operation is required, the results of which may be as satisfactory as those of the former one. No permanent cure, however, can be looked for by this method.

The open operations of most value are removal of the whole of the contracted fascia, and division of the fascia and the skin by a V-shaped incision without removal of any portion of the fascia, so as to enable the finger to be extended.

Excision of the Contracted Fascia.—After the skin has been softened as much as possible in the manner described above, it is disinfected, and a vertical incision is made over the contracted band extending from the root of the finger (or further down, if necessary) to its upper limit; then transverse incisions are made at each end of the vertical incision, so that rectangular flaps of skin can be turned out on each side (see Fig. 88). Any marked horny indurations in the skin over the contracted band should be included in an elliptical incision, and removed at the same time. When the finger is much flexed, considerable difficulty may be experienced in turning aside the skin over the contracted fascia, and it is a good plan to pass a tenotomy knife between the skin and the fascia before making the skin incision so as to separate the two structures from one another ; this, however, should only be done in one or two places, and then very cautiously, because it endangers the vitality of the skin to a certain extent. After the flaps are turned aside, the contracted band of fascia is dissected out, together with all the slips going to the fingers. Subsequently the contracted ligaments around the joint may be divided

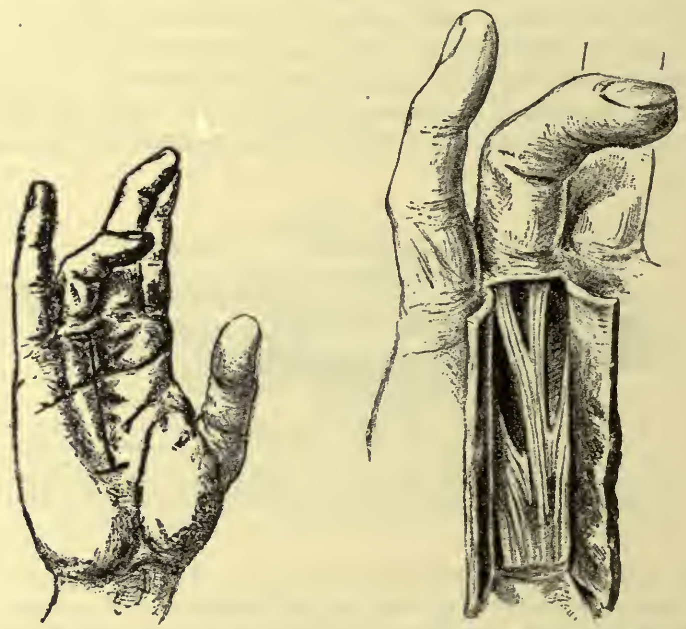
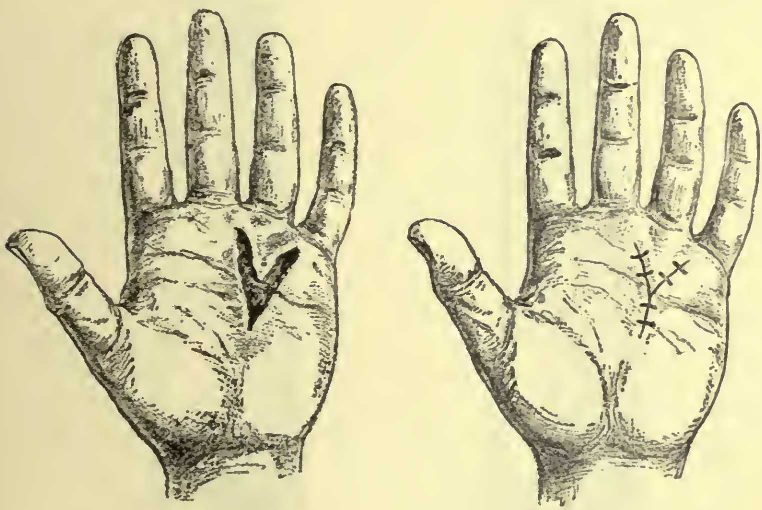


Fig. 88.—Excision of the Palmar Fascia. The left-hand figure shows the incision made over the contracted band of fascia that is to be excised. In the right-hand figure (drawn to a larger scale), the flaps are shown turned aside, and the slips of contracted fascia requiring to be dissected out are seen.

with a tenotomy knife, if this should be found necessary in order to bring the finger straight. This operation can sometimes be performed under local anæsthesia, the whole of the tissues around the contracted band being thoroughly infiltrated with the analgesic solution. The patient can then often help materially by moving the fingers so as to make the various bands stand out one after the other.

It is often difficult to approximate the edges of the wound after the operation, especially when a portion of the skin has been excised. This is largely due to the fact that the skin is contracted in both the transverse and the longitudinal directions. The skin should be sutured as closely as possible, and immediate skin-grafting should be employed for any raw surface left. It is imperative that no granulating surface should remain, as otherwise the scar which forms will materially hamper the progress of the case. If skin-grafting be used, a single graft should be employed if possible. The after-treatment is similar to that for subcutaneous division.

In the other operation, a **V-shaped incision** is made in the palm and carried through both skin and fascia. The apex of the V should be situated in the long axis of the finger which is most contracted and just above the transverse crease of the palm; from this point incisions are carried downwards into the palm on each side, diverging from each



A *B*

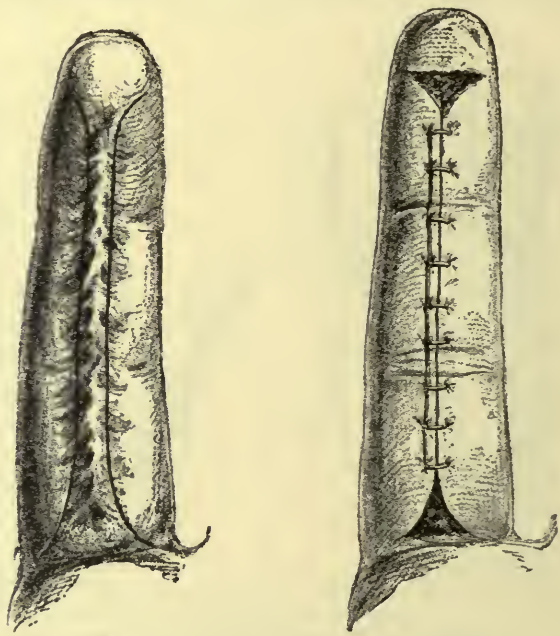
FIG. 89.—THE V OPERATION FOR DUPUYTREN'S CONTRACTION. *A* shows the hand after the incision has been made through the fascia, and the finger straightened. The raw surface thus left is closed by employing sutures in the manner shown in *B*. There is often a small raw surface left at the junction of the three limbs of the Y; this should be covered by a skin-graft.

other and ending about half an inch from the web (see Fig. 89, *A*). The incisions are carried through skin and fascia, the latter being completely divided, and no attempt is made to separate the two structures. The finger can then be extended without tearing or dividing any tight bands. After the finger has been brought straight, a large triangular wound is left in the palm, but this may be stitched together if the skin be supple, so that little or no raw surface is left. The sides of the wound are approximated, and the apex of the V fits in between them where they diverge lower down (see Fig. 89, *B*), so that there may be complete closure of the wound. When the skin is not sufficiently elastic, a certain amount of raw surface is left, which should be covered immediately with a single skin-graft.

The preliminary treatment of the palm, in order to render it supple, is the same as before, and the after-treatment is identical with that for the subcutaneous operation (see p. 293). The immediate result of this operation is usually satisfactory, but here, as in the former case, the contraction tends to recur.

CONTRACTIONS AFTER BURNS.

It is not uncommon, especially in young children, to meet with contraction of the fingers as a result of the cicatricial contraction following



A *B*

FIG. 90.—OPERATION FOR CONTRACTED FINGER AFTER A BURN. *A* shows the incisions for raising the lateral flaps; the portion between them is dissected out. *B* shows the finger straightened after this has been done. The flaps are sutured together throughout most of their extent, the triangular raw surfaces left above and below being covered by skin-grafts.

upon burns. The condition is of the greatest importance because of the resulting uselessness of the hand. The burns are generally produced by grasping something red-hot, such as a poker, or falling on to the bars of a grate, and burning the palmar surface of the fingers. The result is a granulating wound which, when cicatrisation is complete, gives rise to ridges of cicatricial tissue extending from the palmar surface of the tips of the fingers to the palm, the fingers becoming flexed and rigid from the contraction of the scar.

TREATMENT.—The deformity is difficult to remedy. If the bands be divided transversely, recurrence of the contraction will take place almost inevitably as the wound heals, and the deformity will be reproduced. Transverse division of the cicatricial band, followed by immediate skin-grafting of the raw surface, also fails to give a satisfactory result. The best treatment is to dissect out all the cicatricial tissue on the front of the finger, and then to straighten the latter. A considerable time—at least a year—should be allowed to elapse between the completion of cicatrisation and the operation in order to allow the scar to become as supple as possible. The operation may be done as follows. An incision is carried from end to end of the finger upon each side of the central cicatrix, and as near it as possible. These incisions are curved outwards at each end, so that each one nearly reaches the dorsum (see Fig. 90, *A*). In this way a flap is marked out on each side of the finger, and these are dissected up so as to expose all the cicatricial tissue. The central cicatrix and the cicatricial tissue surrounding it are then dissected out, when generally the finger can be brought straight, although it may be necessary to divide, in addition, some of the various ligaments around the joints when the contraction has lasted for a long time. After the finger has been straightened, the flaps may be made to meet in the middle line throughout the greater part of their extent, a triangular raw space being left at either end which must be covered with a skin-graft (see Fig. 90, *B*). The advantage of this plan over that of simple transverse division of the cicatrix followed by skin-grafting is that the raw surface is covered by skin over the centre of the finger corresponding to the middle phalanx, so that no contraction occurs. It is not a matter of great moment should any contraction occur where the skin-grafts have been applied. In order to guard against the tendency to contraction still further, the hand should be put upon an anterior splint, with the finger hyper-extended, until the wound has healed. After about a fortnight's interval, a back splint should be substituted, similar to that described for use in Dupuytren's contraction (see Fig. 87), and to this the finger or fingers are fastened back day and night for six or eight weeks. At the end of the first fortnight, when the wound has healed, the splint should be removed three or four times a day, and careful massage and passive movements carried out. After eight weeks the splint is left off during the day, and the patient encouraged to use the fingers constantly. The splint, however, should be worn at night for six or eight months longer.

CONGENITAL ELEVATION OF THE SCAPULA.

In this deformity the scapula is drawn upwards upon the thoracic wall, by contraction of the muscles at the back of the neck, gliding over the upper ribs until its superior angle can be felt projecting into the posterior triangle of the neck. A cursory examination gives the impression that there is a well-marked exostosis at this point, but careful examination and radiograms show that this is not the case, the unusual appearance being produced by the altered position of the scapula. In many cases the shape of the scapula is unaltered, but in others it is elongated in a direction parallel to the spine, and in rare instances there is a separate ossicle connecting the vertebral border with the spines of the dorsal vertebræ. The muscles which elevate the scapula are contracted and thickened, a point specially noticeable in the trapezius where it bounds the posterior triangle. The lower portion of the trapezius and the muscles which retract the scapula are thin and wasted. This deformity does not give rise to much disability, except that in raising the arm from the side the superior angle impinges upon the vertebral column. This limitation of movement is specially marked when the accessory ossicle is present.

TREATMENT.—Little benefit seems to be obtained by division of the contracted muscles, as their opponents are atrophic; but when the superior angle comes into contact with the spine and limits elevation of the arm, this process may be sawn off with advantage. When an accessory ossicle is present it should be removed.

CHAPTER XV

FLAT FOOT

FLAT foot is essentially an affection of adolescence ; it may, however, occur in comparatively young children, and it is often met with after growth has ceased. It is sometimes spoken of as 'spurious valgus,' but in reality it has nothing in common with true valgus, as it is primarily due to the giving way of the arch of the foot.

CAUSES.—The affection may develop either rapidly or gradually. Acute flat foot is generally the result of some inflammatory condition affecting the structures in the sole, more particularly the calcaneo-scaphoid ligaments ; it is common as a form of gonorrhœal rheumatism, after acute or chronic rheumatism itself, and after any inflammatory conditions about the foot which soften the ligaments. The acute form also occurs in conjunction with such injuries about the ankle joint as Pott's fracture and fracture of the astragalus or os calcis. These cases are sometimes called 'traumatic flat foot.'

In most cases, however, flat foot develops slowly, and is most marked in weakly subjects and in those whose occupations entail prolonged standing, such as barmaids or shop-assistants. In this form the essential factor at work is a gradual weakening of the muscles which should support the tarsal bones. As a result of this failure of muscular power—which may be due either to undue weakness of the muscles or to unduly heavy strains being put upon normal muscles—excessive strain is thrown upon the supporting ligaments of the tarsus with the result that they become stretched and allow the arch of the foot to become flattened. The chronic form is also met with in association with rickets, particularly genu valgum, in which the weight of the body is thrown more upon the inner border of the foot than upon the sole. Any condition which leads to eversion of the foot throws the body weight upon its inner border and favours the production of this deformity. The condition seems to be more common in males than in females.

PATHOLOGICAL CHANGES.—As the result of the yielding of the arch of the foot, the head of the astragalus becomes partially dislocated inwards and downwards from the scaphoid, and in bad cases it may only articulate with the latter at the extreme outer part of the head; in consequence the cartilage disappears from the portion of the bone that is thus exposed, and the head forms a marked prominence beneath the skin on the inner border of the foot. The arch of the foot diminishes, until finally the sole is applied flat to the ground. In well-marked cases the anterior part of the foot becomes abducted, and in very severe ones the inner border of the foot may be actually convex and the outer concave, so that the patient walks more on the inner side of the foot than on the outer, although not to the same degree as in cases of true valgus.

In very severe cases the peronei tendons may be dislocated from their groove and lie upon or anterior to the external malleolus. In cases of long standing, marked changes also occur in the bones; the uncovered portion of the head of the astragalus becomes enlarged, so that it cannot be replaced in position. Sometimes actual bony anchylosis may take place. There may be effusion into the sheaths of the tendons behind the malleoli,

SYMPTOMS.—As flat foot develops, pain is always present although it varies in situation and degree. In the acute form of the disease, the pain is usually so severe that the patient is unable to walk, and it is chiefly felt in the sole beneath the head of the astragalus, where there is also marked tenderness on pressure. This is due to the stretching of the ligaments about the mid-tarsal joint. Pain in the calf from stretching of the muscles is often an early symptom in the chronic cases. In more advanced cases pain is also experienced along the outer side of the metatarsus and about the external malleolus. The pain in the latter situation is often due to actual pressure of the os calcis against the tip of the fibula.

The affection is generally bilateral, but may be unilateral only; it is not at all uncommon for patients to complain of pain on one side only. Many persons with an absolutely flat foot suffer from no symptoms whatever, while others have very severe symptoms when to all appearance the arch is well developed.

TREATMENT.—For the purposes of treatment flat foot may be divided into five stages.

(1) A patient begins, comparatively suddenly, to complain of pain on standing, referred to the centre of the sole. On examination there is tenderness on upward pressure in the sole, and some flattening of the arch of the instep. This is the 'acute flat foot' usually associated with an inflammatory condition of the ligaments supporting the head of the astragalus and in it there is no difficulty in bringing the foot into position and restoring the arch; no bony deformity has yet taken place, nor are there any material changes in the ligaments.

(2) Chronic cases characterised by slight pain, in which the arch can be restored readily by manipulation.

(3) Chronic cases in which there is considerable deformity, and in which the arch can be restored only with difficulty.

(4) Bad cases, with marked deformity which cannot be reduced without employing considerable force.

(5) The most severe cases of all, accompanied by bony deformity or anchlyosis, in which reduction is impossible even after using great force.

Acute Flat Foot.—The treatment must be directed first to the arrest of the inflammatory condition which is the primary cause of the affection ; the arch of the instep must also be supported until the parts have had time to become consolidated. The main essential is rest ; the patient must be prohibited from standing or bearing weight upon the foot. Another essential is to arrest the inflammatory condition causing the trouble. The means at our command for this purpose are numerous, and the choice of the particular form will depend to a large extent upon the cause of the affection.

In *gonorrhœal cases* the treatment must be directed to the general condition as well as to the local disease. This will involve the use of the methods appropriate for the treatment of gonorrhœal diseases of joints and ligaments, which are described in detail in Vol. III. In all cases the patient should be confined to bed, and should lie with the knee bent and the leg resting upon the outer side of the foot—a position somewhat resembling that of the tailor at work. The general treatment most suitable for the condition is the internal administration of quinine and iron, whilst means should be employed to arrest the gonorrhœal discharge (see Vol. V.). Vaccine treatment seems to be of value in some of these cases (see Appendix).

It is essential to remember the great tendency to the occurrence of anchlyosis after gonorrhœal arthritis. Whilst rest is essential in the earlier stages, fixation apparatus, such as plaster of Paris, must be employed with caution and for a short time only. As soon as the arch of the instep is sufficiently maintained by making the patient lie in bed with the knee flexed and the weight of the leg bearing upon the outer border of the foot, it is better to discard all fixation apparatus, and to employ massage and movements. Adhesions in or about the tarsal joints must be broken down as a preliminary measure.

In the ordinary *rheumatic cases*, salicylates should be administered ; hot fomentations are of value if the pain be acute. The patient should be confined to bed, with the knee bent and the foot resting upon its outer side in tailor-fashion for the first few days ; this position alone will almost entirely restore the arch of the instep in these cases.

Fixation.—In all cases of acute flat foot, except those due to gonorrhœa, it is well, when the pain begins to subside, to put the foot up in plaster of Paris with the deformity rather over-corrected—viz. with the arch of the instep somewhat exaggerated. The foot should be kept in the plaster for about three weeks, or at any rate until the acute inflammatory condition has subsided; then massage, douching, and active exercises should be ordered, so as to strengthen the muscles of the foot.

Exercises.—When the patient raises himself upon the toes, the short muscles of the foot are brought into action, and the arch of the foot is increased; exercises like this are of great value. The patient should stand with the feet together, and the toes pointing directly forward, and should then raise himself gently and slowly upon tiptoe, bending the knees

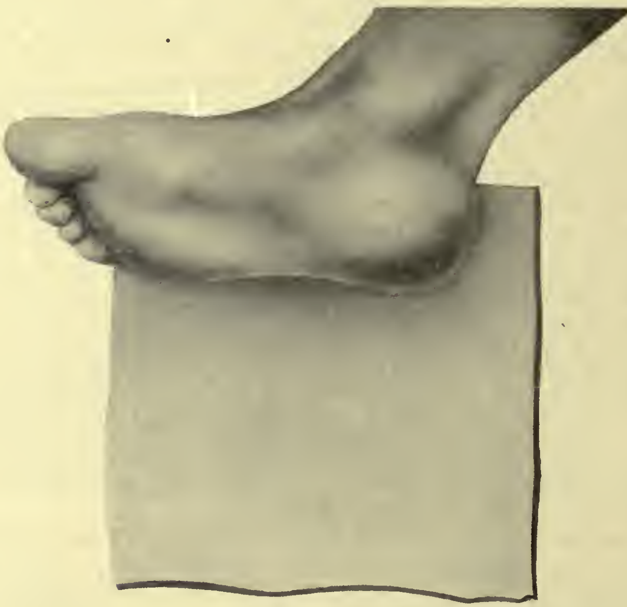


FIG. 91.—WHITMAN'S BRACE. Making a cast of the foot. The foot is laid upon its outer border upon a piece of lint soaked in plaster of Paris.

slightly at the same time. This exercise repeated for a certain number of times—at first from ten to twenty—twice daily, and later on for five or ten minutes at a time two or three times a day, will do much to restore the arch of the foot. Another exercise of considerable value is the following. After the patient has raised himself upon tiptoe in the manner just mentioned, the knees are separated while the feet remain in their original position, so that the lower extremities form a letter O; in other words, a sort of artificial genu varum is formed. This throws the weight of the body upon the outer border of each foot, and so tends to increase the arch of the instep. A third exercise, somewhat similar to the above, consists in standing upon the outer border of the foot with the feet together, the soles being directed inwards towards one another. These exercises should not be carried to the extent of tiring the patient. They should be very light at first and increased gradually; it is better to practise them several times a day for a short time than to have a single long sitting. For a week or two after the plaster casing has been left off, the patient should be content with these exercises, which should be combined with massage and rest, with the limb in the tailor-position; no attempts should be made at walking. As soon, however, as he is allowed to get about, there is no better form of exercise for the foot muscles than bicycling, which may be indulged in freely.

Whitman's Spring.—When the tenderness in the sole has almost disappeared and no adhesions in the tarsal joints remain, the patient may be allowed to walk with a suitable support in the boot. The best

FIG. 92.—WHITMAN'S BRACE. The lint has been folded around the foot and its edge turned down.

form of this is Whitman's spring or 'brace,' the so-called 'artificial instep' (see Fig. 95). The apparatus consists of a support modelled upon a plaster cast of the foot taken whilst the arch of the instep is held in the fully corrected position. It fits the arch of the foot accurately, extending forwards almost to the balls of the toes, outwards round the outer border of the foot, and backwards to just in front of the tuberosity of the os calcis. On the inner side it is enlarged upwards and extends well on to the inner side of the foot. With a properly made support, the weight of the foot is not borne upon the apparatus at all until the arch begins to sink; the foot rests upon its normal bases of support, namely, the under surfaces of the heads of the metatarsal bones and the tuberosities of the os calcis, and the spring only comes into action when the arch of the foot sinks unduly. These springs should be accurately fitted, and each should be specially made for the individual who has to wear it.

A simple method of taking the cast is as follows. The patient sits

FIG. 93.—WHITMAN'S BRACE. The trough-like mould formed after the plaster has set and the foot has been removed from it.

upon a chair with his foot upon a second chair of the same height, and the foot lies upon its outer side at right-angles to the leg (as shown in Fig 91). A mackintosh covered by a newspaper is placed upon the chair under

FIG. 94.—WHITMAN'S BRACE. The mould is filled with a mixture of tow and plaster of Paris, so as to form a cast of the foot.

the foot, the foot is well oiled, and plaster of Paris is mixed with water to form a thick cream; a piece of lint is steeped in the plaster and laid upon the newspaper underneath the foot so that the outer border of the sole rests upon it along a line about an inch from one edge (see Fig. 91). The lint is then wrapped round the foot, covering in the heel behind and extending as far forward as the cleft between the toes; it should reach up just above the internal malleolus, but should not overlap the dorsal surface to any extent. This covering is allowed to set, and when the plaster is hard there is no difficulty in removing the foot from it. A fresh lot of plaster is now made and some tow is mixed in with it. The mould is well oiled, and the mixture of plaster and tow is laid in it and arranged so that it fills the mould but does not project beyond it in any direction. When the plaster mixture has set, the sides of the mould are forced aside and the cast is removed and marked for the instrument-maker. This method of making a cast is much simpler than that described by Whitman and is equally serviceable; an excellent cast can be produced by it without having recourse to skilled assistance.

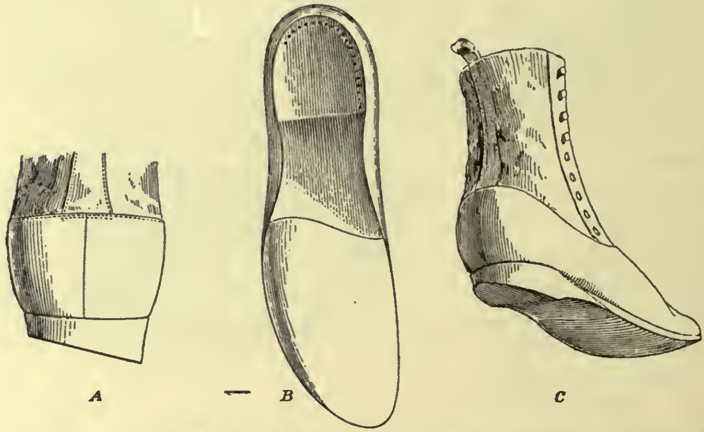
Fig. 95.—Whitman's Brace. The brace moulded upon the cast and viewed from the outer, plantar, and inner aspects respectively.

The brace is made of thin steel[1] and should extend forwards to the line of the metatarso-phalangeal joint of the great toe and backwards to the centre of the heel; on the inner side of the foot it extends upwards to half an inch below the internal malleolus and on the outer side grasps the foot just behind the prominence formed by the fifth metatarsal. It should be

[1] It may also be made of aluminium or phosphor-bronze; these materials do not rust.

made to fit the cast accurately except over the heel, where it should be slightly flattened so as to make it steadier.

A badly fitting apparatus extends either too far forwards or too far backwards, and causes so much pain that the patient is unable to wear it; when it fits properly, however, the patient soon becomes accustomed to it and cannot do without it. Sometimes it causes a little discomfort at first, and, until the patient has become accustomed to it, it should only be worn for short periods at a time, the length of time being gradually increased as tolerance is established. It should be worn in the house-shoes as well as in the boots, as long as there is any tendency to sinking in the arch of the foot.



A *B* *C*

FIG. 96.—BOOTS FOR USE IN FLAT FOOT. *A* shows the obliquity of the heel from the back. *B* shows both the obliquity of the heel and the filling up of the waist of the boot by carrying the heel forward beneath the arch of the instep to join the sole. This is well seen in *C*, which is a view of the boot from its inner side. (*Modified from Hoffa.*)

Boots.—The sole of the boot should also be strengthened beneath the instep by continuing the heel forwards on the inner side until it meets the front part of the sole; it is also of advantage to make the sole and heel thicker on the inner side than on the outer, so as to raise the inner border of the foot (see Fig. 96). The patient should be cautioned not to turn the toes out whilst walking; they should be directed straight forwards, and the knees should be rotated slightly inwards. It is also well to direct the patient to raise himself on tip-toe from time to time when walking, and to walk rather upon the toes than flat upon the sole. He should not walk too far at first, and should never be allowed to continue walking until the foot feels tired; the amount of exercise should be prolonged gradually.

When the condition is chronic, when there is but little pain, and when the arch can be restored readily to its normal condition, it is not necessary to employ absolute rest in bed with fixation in plaster of Paris. Any adhesions in the tarsal joints that may exist should be broken down under anæsthesia by grasping the foot with the two hands and moving the front half upon the back freely and in all directions. Then the exercises above described should be carried out, friction, massage, and douching should be employed, and gentle exercise encouraged while the patient is wearing a Whitman's spring. In these cases treatment must be continued for a long time; indeed, many patients must use a spring for the rest of their lives both in their walking boots and their house-shoes. Any co-existing causes of flat foot must be remedied if possible. Should the patient be weak or anæmic, iron may be administered, and any deformity, such as genu valgum, which may be the cause of the affection, must receive appropriate treatment; it is futile to treat a case of flat foot depending upon genu valgum without removing the primary cause.

When there is marked obliteration of the arch accompanied by considerable eversion of the foot, and when there is also difficulty in restoring the arch by manipulation, it may be necessary to have recourse to some form of elastic traction in order to support the instep. The same method may also be called for when Whitman's spring gives rise to much pain. A good apparatus for this purpose is Golding Bird's modification of Barwell's spring, which is essentially an artificial tibialis anticus muscle (see Fig. 97). It consists of a sling of webbing encircling the ankle and passing down across the outer border of the foot and beneath the arch of the instep, terminating on the inner side just above the head of the astragalus in a hook to which is fastened one end of a stout india-rubber door-spring; the other end of this is attached to an outside leg-iron which is hinged into the heel of the boot below, and fastened to a band encircling the leg just opposite the tubercle of the tibia. The apparatus is applied as follows. The sling is arranged around the ankle and beneath the instep outside the stocking, and the boot is put on and the leg-iron adjusted to the heel whilst the free end is pulled upon firmly. The elastic band is then fastened in position, and the upper end of the leg-iron is adjusted. A slit must be made in the upper leather of the boot through which the free end of the sling is passed before the spring is attached to it. This apparatus supports the arch of the foot well, and without pain. At the same time it is cumbrous and expensive, and we do not advise its use when the metal spring will answer its purpose. It is, however, a good method

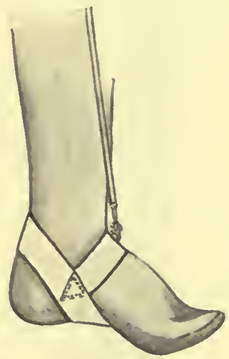


FIG. 97.—GOLDING BIRD'S APPARATUS FOR FLAT FOOT. The sling applied.

when there is much spasm and pain. The accessory methods of treatment are similar to those already described for the milder cases.

In the still more advanced cases, when it is impossible to restore the arch of the instep by manipulation, and when the deformity is associated with shortening of the ligamentous structures on the outer side of the foot, as well as spasm of the peroneal muscles in some cases, the tense structures should be stretched fully. The patient should be placed under an anæsthetic, and the foot manipulated in all directions, so as to break down any adhesions that may be present. The inner side of the foot should then be fixed by pressing it firmly against the surgeon's knee, whilst the front of the foot is grasped with one hand and the heel with the other and the abduction of the front half of the foot is forcibly over-corrected. This often calls for the exercise of considerable force. If mere manipulation of this kind does not enable the surgeon to restore the arch of the instep satisfactorily, still greater force must be employed to stretch or break through the resisting structures by means of a Thomas's wrench (see Fig. 116), which is adjusted to the anterior part of the foot, and by means of which the parts may be brought forcibly into position. After this has been done, the foot should be put up in plaster of Paris, with the deformity over-corrected, for about six weeks. It is well to renew the casing every ten days, as it is apt to get loose, and in these intervals massage and passive movements in all directions should be practised. When the splint is left off, tiptoe exercises (see p. 302) should be combined with douching and massage. The arch of the instep should be supported in the first place by Golding Bird's apparatus, for which Whitman's spring may be substituted when the parts become more consolidated. The general treatment is similar to that already described.

Fig. 98.—Golding Bird's Apparatus for Flat Foot. The sketch shows how the sling is brought through a slit in the boot and fastened to an external iron.

In the worst cases, in which even forcible manipulation by a Thomas's wrench fails to bring the parts into position, the treatment is most difficult. The bony deformity is extreme, and the pain and disability from which the patient suffers may be so great that some form of operative procedure becomes necessary. Some surgeons advocate excision of the astragalo-scaphoid articulation, some remove a wedge from the neck of the astragalus, whilst others excise a wedge-shaped portion of the tarsus, without regard to the structures removed. The operations most generally useful are the removal of the head of the astragalus, or a partial excision of the astragalo-scaphoid joint as described by Ogston.

Excision of the Head of the Astragalus.—This is perhaps the best operation on the whole. It can be done readily by an incision similar to that required for Ogston's operation (*vide infra*), and is not necessarily followed by anchylosis. The disadvantage of the operation is that there is a tendency for depression of the arch to recur as a result of the absence of anchylosis, and therefore a Whitman's spring must be worn constantly after the operation.

Ogston's Operation aims at producing bony anchylosis between the scaphoid and the astragalus, after the foot has been got into position. It is performed as follows. Under full anæsthesia any adhesions present are broken down by free and forcible movements in all directions. Then an attempt is made to rectify the position of the foot as far as possible by means of the hand, aided, if necessary, by a wrench. An incision is then made along the inner aspect of the foot, from just below the anterior margin of the internal malleolus, downwards and forwards to a point beyond the tubercle of the scaphoid. The tendon of the tibialis anticus must be avoided in deepening the incision ; it can be drawn aside with a retractor. The astragalo-scaphoid joint is then opened, and the whole of the articular cartilage covering the head of the astragalus and the corresponding part of the scaphoid, is stripped off with a periosteum detacher or a chisel. If the altered shape and increased size of the astragalus still renders it impossible to bring the foot into position, enough of that bone may be removed with a chisel to enable this to be effected. The foot is then forcibly inverted and adducted, and the arch of the instep is raised by depressing the metatarsal bones ; when the position appears to be satisfactory, a hole is drilled through the scaphoid from before backwards and outwards and continued on into the head of the astragalus. Through this is inserted an ivory peg, a screw, or a nail, which serves to keep the bones steady in their new position ; whichever of these be used to fix the bones, its inner end should lie flush with the scaphoid. The wound is closed without a drainage-tube, and outside the dressings is applied a plaster of Paris casing, extending from the base of the toes up to about the centre of the calf ; the foot is held in its new position while the plaster sets.

The casing need not be disturbed for about six weeks if no pain be complained of. Bony union should then be fairly complete, and the patient may be allowed to walk. Should there be any pain, however, or should the casing become loose, it must be removed, the wound re-dressed, and a fresh casing applied. After the casing has been left off, the arch of the instep should be supported by a Whitman's spring, but this can generally be discarded in about two months. The boots should have a high arch to the instep, and the latter should be supported still further by extending the heel forwards (see p. 306).

The objections urged against this operation are that in bad cases it is not always easy to bring the foot into proper position after it, and that the transverse tarsal joint loses its mobility, and therefore the foot is deprived of some of its normal elasticity. Nevertheless, it effects a great improvement in the condition of the patient, and it gives better results than any that can be obtained by mechanical means in cases which have reached this degree of severity.

Removal of a Wedge-shaped Portion of the Tarsus.—In cases of the most severe type of all, the only chance of a successful result is by the removal of a wedge-shaped piece of the tarsus, the base of the wedge being on the inner side of the foot, and the apex at the outer. This operation is performed in a similar manner to that described for bad cases of talipes varus (see p. 358), except that in the latter case the base of the wedge is on the outer side of the foot, and we may therefore refer to the description there given. As a result of this operation the bones become anchylosed, but the patient is really much more comfortable if the foot has been brought into accurate position, notwithstanding anchylosis. Other operations, such as Stokes's excision of a wedge from the neck of the astragalus, excision of the astragalus, or of various tarsal bones, have nothing to recommend them in preference to the procedures already described.

WEAK ANKLES.

In this condition, which is common in young children, the child habitually walks on one side of the foot producing an apparent valgus or varus. The deformity can be readily distinguished from a true talipes by the ease with which it can be corrected. The child wears the soles of his boots irregularly, and the uneven basis of support thus produced tends to confirm the habit and aggravate the condition. The essential trouble in these cases is muscular weakness.

TREATMENT.—This must be directed in the first place to the general muscular system, and in the second to any group or groups of muscles that are specially at fault. The patient should be put in healthy surroundings and should have simple nourishing food and active outdoor exercise, which should never be pushed to the point of fatigue. Little children who are supposed to be delicate are often loaded with excessive garments under the mistaken impression that they need special warmth ; clothing should of course be warm, but it must be light so as not to impede the patient's activity. In the intervals between the periods of activity rest must be insisted upon. In many cases attention to these points is all that is required, but this general treatment may be supplemented by a system of exercises designed to improve the general muscular power. A list of such exercises will be found under Scoliosis (p. 423). Massage of the legs is also of value.

In addition, the child should wear strong boots which are frequently mended and prevented from irregular wear by metal plates. In the country the child may wear sandals or go barefoot.

INTOEING.

This condition is often difficult to correct, the child walking with the toes pointing inwards, so that when he attempts to run he trips over his own feet and falls.

TREATMENT.—General treatment on the lines mentioned above is of value, but in addition it is usually necessary to provide some means of rotating the feet outwards, and for this purpose the apparatus shown in Fig. 99 is useful. A band of elastic webbing is fastened to the outer side of the toe of the boot and then wound round the leg, passing behind the knee and over the front of the thigh, to end at a point in the middle of the back, where it is fixed to a belt or to the child's braces; this is kept tight and exerts a steady external pull sufficient to correct the deformity.

Fig. 99.—WHITMAN'S APPARATUS FOR INTOEING.—The photograph shows the apparatus as constructed by the parent of an out-patient. Bands of elastic are fastened to the outer parts of the boots and then wound spirally around the limbs, being attached above to the back of the girdle.

CHAPTER XVI.

CLUB-FOOT.

By the term Club-foot or Talipes is understood a permanent deformity of such a nature that the foot is inclined at an angle to the leg, so that the sole no longer rests upon the ground in the normal position when the patient bears his weight upon it. The directions in which the foot may be displaced are various, and the displacements may be either simple or complex. Of the simple forms of club-foot we may enumerate *Talipes Equinus*, in which the heel is drawn up and the toes are pointed, the patient walking upon the extremities of the metatarsal bones; *Talipes Calcaneus*, in which the reverse condition exists, the front part of the foot being drawn up and the patient walking upon the heel; *Talipes Varus*, in which the foot is inverted, and the patient walks upon its outer border; and *Talipes Valgus*, in which the foot is everted, and the patient walks upon the inner border. In the great majority of cases, however, the deformity is a mixed one, the most frequent being *Talipes Equino-varus*, which is a combination of talipes equinus with varus. *Talipes Equino-valgus*, *Talipes Calcaneo-valgus*, and various other less important forms are also met with; there is also the affection known as *Pes Cavus*, or hollow club-foot, in which the arch of the instep is exaggerated and the plantar fascia is shortened. The cases of club-foot may be divided into two great classes, namely, the congenital form, in which the condition is present at birth, and the acquired one, in which the affection develops at a later period.

CAUSES AND PATHOLOGICAL CHANGES.—**Congenital talipes** is probably due primarily to some arrest of development in the fœtus more particularly to failure of the foot to rotate from its fœtal to its post-natal position. During early intra-uterine life, the feet lie in a position closely resembling talipes equino-varus, but shortly before birth the lower extremity becomes rotated in such a manner that the foot assumes its normal position; if from any cause this rotation does not take place, congenital talipes equino-varus is the result. Congenital club-foot may also be associated with imperfect development of the bones of the leg; thus absence of the fibula may give rise to a talipes valgus, and absence of the tibia may give rise to a talipes varus. The latter condition is very rare.

In most cases of congenital talipes there is imperfect development of some of the bones of the foot. This is most marked in the astragalus and takes the form of an actual alteration in the axes of the bones; at first, at any rate, the muscles are not altered in length. In addition to the alteration in the shape of the bones, shortening of some of the ligaments occurs rapidly, and if the deformity be uncorrected, the shortening of the ligaments becomes still more marked as time goes on, whilst the muscles, accommodating themselves to the altered position of the limb, may also become permanently altered in length. It is of great importance in the treatment to remember that, while we have only to do with a faulty shape and position of the bones in the early stages, in later life there is, in addition, a permanent shortening of the muscles, fasciæ, and ligaments. The bony deformity increases and becomes permanent and, if the patient be allowed to attain adult life with the foot in its faulty position, the shape of the bones and the position of their articular surfaces are so completely altered that some radical operation is required to rectify the condition.

Of **acquired club-foot** there are numerous causes. The most frequent form is the *paralytic*, resulting from the paralysis of certain groups of muscles, generally due to infantile paralysis; the muscles most frequently affected are those of the front and outer aspects of the leg. As a sequel to the loss of power in the muscles, the foot assumes a faulty position by its mere weight. Later on, the unaffected muscles become shortened, their action being unbalanced by the paralysed ones, and the condition present is then one of permanent contraction of the active muscles, and over-stretching and degeneration of the affected ones. As the case progresses, the structure and direction of the articular surfaces of the bones become altered unless steps be taken to keep the foot in proper position.

Another cause of the paralytic form of the deformity is *injury to a nerve trunk*, such as a gun-shot or other wound, or a fracture involving the nerve. In other cases, the deformity may result from *spastic contraction* of certain muscles due to various causes, such as affections of the central nervous system. Talipes may also be one of the manifestations of *hysteria*. Again, the deformity may be caused by *myositis* due to the presence of an inflammatory focus in the affected muscles or their vicinity which leads to their contraction, or it may result from inflammation in the neighbourhood of tendons giving rise to adhesions while the foot is in a faulty position. Occasionally also club-foot may be due to the condition known as 'ischæmic paralysis' (see Vol. II.).

There are also many other less frequent causes of talipes. For example, it may result from the contraction of *cicatrices* after wounds, ulcers of the leg, burns, etc., or as the result of *joint diseases* in which proper attention has not been paid to the position of the foot, and sometimes also it may occur from the long-continued assumption of a faulty position without any disease in the ankle. In these cases, the usual deformity seen is talipes equinus, which is due to the natural pointing of the toes, aided in many cases by the weight of the bed-clothes. Again, in cases of marked *ricketty curvatures* of the lower extremity, there is often some form of talipes present, particularly valgus. The affection may also occur as the result of *osteitis*; acute osteo-myelitis affecting only one of the bones of the leg may cause the destruction of the epiphyseal line in the affected bone, so that there is arrest of growth in it; the result is that the foot will be displaced as the other bone grows, and talipes will ensue. It is quite common as a result of fractures about the ankle joint when reduction has not been satisfactory.

TREATMENT.—**General Indications.**—If the affection be of **congenital** origin, the treatment in the earlier stages need not be directed so much against contraction of the muscles as against the alterations which have occurred in the shape of the bones, and its aim must be to rectify the altered direction of these whilst they are still soft. If, however, the condition remains untreated until later life, a satisfactory result may only be obtainable by an operation dealing with tendons as well as the bones. In the **acquired** variety, on the other hand, the primary lesions are usually situated in the muscles and soft parts, and the alteration in the shape and structure of the bones only occurs when the deformity has been allowed to continue for a considerable time; hence, in the early stage the chief attention must be directed to the muscles and ligaments. In the *spastic* cases, means must be taken to relieve the spasm, while at the same time division of some of the tendons may be necessary. When the club-foot is of *paralytic* origin, the chief point in the treatment is to restore the power of the muscles by massage, electricity, and the use of suitable apparatus to prevent over-stretching of the weak muscles and undue contraction of the sound ones. Much of the disability may be due to the fact that certain muscles are overstretched, and appropriate splinting, by relaxing their tendons, may be followed by extensive recovery of function. By means of tendon transplantation also, healthy muscles may be made to perform the functions of paralysed ones, while arthrodesis, or removal of the articular cartilage, may be required to transform certain flail-like joints in which all the muscles concerned are paralysed, into fixed ones (see p. 341). Occasionally also it may be possible to improve matters by grafting a sound nerve into the paralysed one. When the affection is caused by *cicatrices*, these must be removed or divided.

The earlier the treatment is begun, the better is the prospect of a good result, for, if the early stages be neglected, the final result is alteration in the bones and the articular surfaces, and shortening of ligaments and tendons, whatever may have been the primary lesion. Simple division of the tendons or ligaments, manipulations, and the use of apparatus then fail to restore the foot to its proper position, and more severe measures must be employed.

GENERAL POINTS IN THE TREATMENT OF CONGENITAL CLUB-FOOT.

These cases fall into three distinct groups. (1) Those in which the deformity can be rectified by manipulation alone; in these cases there are no shortened structures to impede the re-position of the foot, and the deformity in the bones is only slight.

(2) Cases of long standing in which there is shortening of the muscles and ligaments, resulting from the long-continued faulty position of the limb; when these contracted structures have been divided, the foot can be got into position with a little effort, the alterations in the bones not yet being advanced enough to offer any great impediment.

(3) The third group consists of cases of very long standing in which the obstacles to reduction are not merely tight muscles, ligaments, and fasciæ, but also alterations in the direction and extent of the articular surfaces which have become so pronounced that re-position is impossible without operation. These alterations in the bones are partly changes in their shape and direction, and partly alterations in the articular cartilages. When, as the result of the faulty position of the foot, a portion of the articular cartilage has remained for a long time out of contact with the articular surface of the corresponding bone, fibroid changes occur in it converting it into fibro-cartilage; ultimately the whole of the uncovered portion of the articular surface becomes denuded of cartilage. Thus, the opposed surfaces are no longer covered with articular cartilage even when the bones are in proper position. Moreover, there are often alterations in the shape of the bone beneath, so that it is no longer possible to bring the two joint surfaces into proper relation with each other unless some alteration is made in their shape. In severe cases the entire limb may be rotated, and it will be necessary to correct this before locomotion will become normal.

It is very important to remember that the patient must not be regarded as cured as soon as the foot has been got into position, or even after it has been maintained there for some weeks. If treatment be left off too soon, a relapse takes place almost at once, and the subsequent condition may become as bad as or even worse than if no treatment had been employed. Hence, it must be impressed on the parents that the treatment should be continued for several years at least after apparently complete recovery.

In the cases in which it is possible to get the foot into position without the exercise of any force, the treatment will consist in the methodical employment of manipulations, so as to keep the parts stretched, and the adoption of means designed to strengthen the action of any muscles that may be deficient in power; besides this, the bony deformity which already exists must be corrected, and prevented from recurring. The first two objects are attained by the use of suitable *manipulations* and massage, whilst for the third some form of apparatus must be employed.

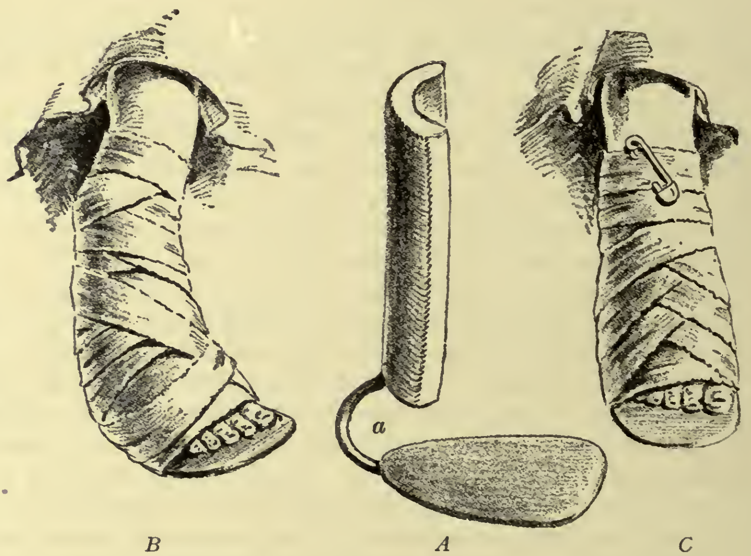


FIG. 100.—METAL TALIPES SPLINT. *A* shows the splint before application. *B* illustrates the splint applied to the foot while still in its faulty position. The splint is easily made to fit the foot by bending the stout copper connecting wire *a*. *C* shows the faulty position of the foot rectified by bending the splint back into the position shown in *A*, while the foot is firmly fixed to it.

When congenital club-foot is detected early enough to be remediable by the hand, the position of the foot should be over-corrected several times a day. It is of great advantage that this correction should be carried out, in the first instance at any rate, by the medical man himself; it should be done by grasping the anterior half of the foot with one hand and gently, firmly, and slowly bringing it into its proper position, whilst the posterior half is fixed by the other hand. It is essential that these manipulations should be carried out without using any force, as spasm of the muscles is at once set up if it be done roughly; this interferes with the proper replacement, and soon teaches the child to resent the manipulations, so that after a few days no further progress is made. The foot should be, so to speak, rather coaxed than forced into its proper position; after the foot has been brought into position it should be held there for ten minutes. It will usually be found that re-position can be effected readily, and the child does not object to the renewal of the manipulations on subsequent occasions, and in the course of a few days it will be possible to over-correct the deformity without exciting spasm of the muscles; this should be aimed at in all cases. The nurse should rub the leg gently and knead the muscles on the side opposite the deformity firmly with the view of increasing their power and enabling them to keep the foot in position.

FIG. 101.—SPLINT FOR TALIPES. This is similar to the one in the preceding figure, except that it has a projecting rim along the inner border of the foot-piece, which is very useful for keeping the foot in place.

These manipulations, however, are not sufficient to lead to a permanent cure, and in the intervals between their employment the foot should be fixed in its normal position, or, if possible, in one in which the deformity is somewhat over-corrected; a constant gentle pressure is thus exerted, and the soft cartilaginous bones are gradually moulded into their normal shape. In the early stages this is done better by a light splint than by any complicated apparatus, which, owing to the small size of the foot, is not likely to keep its proper place. The *splint* which we prefer (see Fig. 100), consists of a light metal leg-piece which is moulded to the back of the leg from just above the os calcis to the upper part of the calf, and a flat foot-piece cut to the shape of the foot; these two portions are connected by a stout copper wire bent as shown in the figure, and strong enough to resist the action of the muscles, but at the same time pliable enough to be bent by the nurse. The splint is padded with chamois leather, and the wire bent so that the splint fits the foot whilst the latter is in the faulty position. The foot and leg are then fastened firmly to the splint by bandages, and the nurse grasps the foot-piece with one hand, and the leg-piece with the other, gradually bringing the splint, and with it the foot, into its normal position; after a few days the limb may be brought into a position of over-correction. The copper wire connecting the two portions of the splint is sufficiently stout to retain its new position, and resist the tendency of the muscles to reproduce the deformity.

The splint should be taken off two or three times a day to permit of the manipulations referred to above, and should be bent back into the faulty position before being re-applied; it is then fixed on the leg and foot, and the limb afterwards brought into the over-corrected position.

The reasons for preferring this splint to plaster of Paris are given on p. 348.

It is also advisable to employ daily *massage* designed to maintain the power of the muscles, which are to some extent interfered with while the limb is on the splint. Benefit may be obtained from the *galvanic current* when the muscular action is feeble. It should be applied daily, for about ten minutes at a time, to the muscles both at the back and in front of the limb. When the child is old enough to walk, a Scarpa's shoe (see Fig. 117) may be employed; and, in addition, *exercises*, such as tiptoe exercises, rising on the outside of the foot, etc., varying according to the nature of the deformity, should be practised. More detailed information upon these points is given in connection with the treatment of the individual forms of club-foot.

In the second group of cases there are structures which definitely resist re-position and means must be taken to overcome them. This is best done by the use of a tenotomy knife. The methods of performing *tenotomy* in various situations are referred to in detail in connection with the individual forms of club-foot. The resisting structures are divided freely, and the foot is put up on a suitable *splint* in the corrected position, which is exchanged later on for one of over-correction. Whether complete correction should be carried out at once, or should be delayed for a few days, depends upon the circumstances of the case. When the contraction is extreme, immediate and complete correction is sometimes inadvisable, especially when the tendo Achillis is affected, for if immediate correction be made, there may be either no union at all or else that which occurs may be long, imperfect, and weak, and may lead to a deformity of the opposite kind. In most of the other tendons, however, and in all cases in which the contraction is not very great, there is a considerable advantage in putting up the foot in the corrected position immediately and substituting a position of over-correction for this in a few days. After union between the divided ends has taken place, as it usually does in two to three weeks, careful manipulations, massage, electricity, and the application of apparatus should be begun. When the patient is old enough to walk, a suitable mechanical arrangement permitting the use of the joints within normal limits should be combined with the other forms of treatment. These are referred to in detail in connection with the individual forms of the deformity.

The plan of rectifying the deformity in this group of cases without any cutting operation has been strongly advocated by some surgeons. The foot is forcibly wrenched and bent against a firm support, until the parts are so stretched that the deformity is over-corrected. The foot is then put up in plaster of Paris or on a suitable splint. Although some amount of forcible stretching and wrenching may be of considerable advantage in these cases, we prefer the use of the tenotomy knife as being more precise in its action and less likely to do serious damage. With forcible wrenching alone the bruising is very severe.

In the third and most severe class of cases the treatment will vary with the amount of deformity present, but as a rule division of tendons, fasciæ, and ligaments, and the subsequent use of manipulations and retentive apparatus are not sufficient, and *extensive operations*, involving division of numerous ligaments and other structures about the foot, or in some cases even the removal of part or the whole of the affected bones may be called for. The precise indications for the various operations are given in connection with the different forms of club-foot. It is in the severe and long-standing cases of equino-varus that these procedures are most often called for, but they are sometimes found necessary in other varieties of club-foot when the deformity has been allowed to remain uncorrected for a long time.

GENERAL POINTS IN THE TREATMENT OF ACQUIRED CLUB-FOOT.

The treatment will vary considerably with the particular case under notice. For example, in the **paralytic form**, in which the deformity is primarily due to paralysis of one group of muscles, with unbalanced action of the opposing groups, the object of treatment must be to maintain the foot in its proper position, and to restore the functions of the paralysed muscles, or replace them by suitable apparatus. In the early stages of this form it is always easy to correct the deformity without using any force and without putting any muscles, tendons, or fibrous structures on the stretch. When the deformity has been allowed to persist for a considerable time, however, shortening of certain muscles and fibrous structures takes place, and these must be divided before the foot can be brought into position. In the early stage, therefore, the means, already indicated (see p. 314), for maintaining and improving the nutrition of the paralysed muscles must be adopted ; it will be necessary in addition to employ some apparatus to prevent recurrence of the deformity. When a secondary contraction of muscles, fasciæ, or ligaments has taken place, tenotomy will be called for, and then the treatment is much the same as in the second group of congenital cases (see p. 318).

In the **spastic cases** the treatment is directed first to the cure of the spasm, which unfortunately is not easy. Tenotomy is often of benefit especially in the early stages ; division of a tight tendon not only enables the foot to be restored to its proper position, but seems to have a curative effect upon the spasmodic condition itself. Care is necessary in the after-treatment to prevent undue elongation of the uniting medium.

When the deformity is due to **cicatricial contraction**, (*e.g.* after ulcers or burns), plastic operations may be required. The nature of the operation depends so much upon the amount and position of the contracted material that it is difficult to lay down any special rules. In these cases prevention is the only really satisfactory treatment, and therefore skin-grafting should be employed quite early in all ulcers or burns of any size about the lower third of the leg, and a suitable apparatus applied so as to prevent the contraction which is otherwise certain to follow cicatrisation. When contraction has occurred and has lasted some time, the muscles become shortened and the fascia tense, and, even although the cicatrix which was the original cause of the trouble be dissected away, the mal-position of the foot is not relieved thereby, and some more radical operation must be undertaken for its rectification. Sometimes it is possible to dissect away the scar and the deep fascia, and to bring the foot into position by manipulations, wrenching or division of tendons or fasciæ. Further, recurrence of the deformity may be avoided by employing skin-grafting and keeping the foot in the over-corrected position during the healing process and for some time afterwards. In many cases, however, it is impossible to bring the foot into proper position in spite of free removal of the cicatrix and the fascia, followed by wrenching; if the disability caused by the deformity be very great it will be necessary to resort to some more severe procedure, such as removal of portions of bones, or even amputation.

In bad cicatricial deformities about the back and sides of the leg in the neighbourhood of the ankle joint, removal of an inch or two of the tibia and fibula will sometimes enable the foot to be brought to a right angle, or even actually into its normal position. The result, however, is not quite satisfactory as a rule for two reasons: in the first place the contraction extends to the ankle joint itself, so that the rigidity of the parts in the neighbourhood of the joint may still prevent the foot being brought into proper position, even when the leg has been shortened sufficiently to prevent the contracted tissues from displacing the foot; in the second place it is very difficult to get the foot into position after the bones of the leg have been divided, for the lower fragments of the tibia and fibula are so short that it is impossible to get a proper purchase upon them in order to move the ankle joint, and break down adhesions in it. This operation, however, has been done with marked benefit; the cases in which it is most likely to be successful are those in which there is a certain amount of movement in the ankle when the knee is fully flexed, so that the front of the foot can be brought up to some extent. In the majority of these cases the main deformity is that of talipes equinus, with possibly a little tendency to varus, and therefore it is more a question of getting the foot to a right angle than of overcoming any lateral displacement.

This operation is done through a vertical incision along the anterior border of the tibia, and a second one along the outer aspect of the fibula;

the periosteum is separated and the requisite amount of bone removed. It is well to make the section of the tibia oblique, so as to provide a larger surface for coaptation and fixation. The fibula should be cut across with bone forceps or a saw in the first instance, and when the required amount of the tibia has been removed it will be seen how much of the fibula must be excised. Full details of the methods of fixing the ends of the bone are given in connection with Ununited Fractures (see Vol. II.). The limb should be put up with the foot at a right angle, and any lateral displacement remedied by side splints ; in a fortnight the splints may be replaced by a suitable plaster of Paris casing which should be kept on for at least eight weeks. Owing to the slowness with which union occurs under these circumstances it is impossible to dispense with the apparatus earlier, and, owing to the liability to non-union after an operation of this kind, it is useless to attempt to promote the movements of the ankle joint until the union of the bones of the leg is complete. As soon as this has occurred, passive movement must be begun, and it will usually be found that the degree of mobility present in the ankle before the operation will still remain. Careful movement and massage, and later on forcible movements under an anæsthetic, may possibly increase the range of movement thus obtained.

When the ulceration, or the burn, is situated upon the foot itself, the bone calling for removal will generally be the astragalus, but the actual operation required will depend upon the nature of the deformity and the situation of the cicatrix. In some cases amputation will be the better practice, but no definite rules can be laid down, on account of the great variety of conditions that may be met with.

THE INDIVIDUAL FORMS OF CLUB-FOOT.

TALIPES EQUINUS.

In this form the heel is drawn up and the toes are pointed. The condition is rarely congenital ; it usually results from some inflammation in the calf muscles or in their vicinity, which leads to their contraction. It may also be a sequel to infantile paralysis affecting the anterior group of leg muscles, cicatricial contraction of ulcers or wounds in the calf of the leg, or to pointing of the foot during a long illness, in which care has not been taken to keep the pressure of the bed-clothes off the toes. It may also occur in connection with disease of the ankle or the tarsal joints in which a secondary contraction of the muscles of the calf has occurred.

Talipes equinus varies in degree ; sometimes the heel may be drawn up to such an extent that the sole of the foot is almost in the same plane as the back of the leg ; sometimes the chief trouble is that the foot cannot be dorsi-flexed beyond a right angle. In the severe cases the patient walks upon the balls of the toes, the phalanges of which are generally hyper-extended upon the metatarsals by the pull of the extensor muscles ; locomotion is interfered with, partly by the increased length of the lower extremity and the small basis upon which the patient stands, and partly by the formation of callosities and bursæ over the ends of the metatarsal bones, and the frequent attacks of inflammation and suppuration which their presence entails.

In the milder cases the sole is applied normally to the ground when the patient stands, but in the act of walking the weight is borne mainly upon the front half of the foot, the heel being drawn up off the ground to a slight extent. This causes the patient to limp, and gives rise to pain in the back of the leg and about the heel which is due to stretching of the calf muscles.

In the slighter cases and in those in which the deformity has lasted only a short time, the essential obstacle to the reduction of the deformity is the undue tension of the tendo Achillis. When the deformity is more marked, and particularly when it has lasted for a considerable time, certain secondary changes take place. In very long-standing cases, especially those in which the deformity is extreme, the upper articular surface of the astragalus becomes altered both in shape and structure. The chief change takes place anteriorly, where the cartilage which normally covers it becomes converted into fibrous tissue, and that portion of the articular surface which the new position of the foot has forced out of contact with the lower end of the tibia becomes enlarged, so that it is impossible for the astragalus to pass back into position, even when all the causes producing the deformity have been removed.

Another important change is contraction of the plantar fascia, which leads to an exaggeration of the arch of the instep, and ultimately produces the condition known as *talipes cavus*, or hollow club-foot (see p. 334). This causes pain in the sole on walking, due to stretching of the shortened plantar fascia ; callosities also develop over the heads of the metatarsal bones and give rise to pain. In some cases also, permanent shortening of the long flexors of the toes and of the peroneus longus takes place, whilst, in addition, inversion of the foot at the mid-tarsal joint may occur, producing a condition of talipes equino-varus.

TREATMENT.—From the point of view of treatment talipes equinus may be divided into three classes. (1) The mild cases, in which the foot cannot be dorsi-flexed beyond a right angle, but in which there is no contraction of any other structures than the calf muscles.

(2) The more severe cases, in which the heel is considerably drawn up and in which there is also secondary contraction of other structures, such as the plantar fascia, and possibly also some of the muscles already mentioned.

(3) The most severe cases of all, in which the elevation of the heel is extreme, and in which the affection has lasted long enough for profound

alterations to have occurred in the bones and the articular surfaces; in these cases, re-position of the foot is extremely difficult.

In the first group, the tendo Achillis should be divided, and then the foot maintained in position by suitable apparatus and suitably exercised meanwhile. Some authorities employ exercises alone so as to stretch the calf muscles gradually, and advise that tenotomy should not be done. In some cases it may be possible to overcome the trouble in this way, but on the whole it is neither a satisfactory nor a safe procedure. The constant pulling upon a tight tendon may set up spastic contraction in the calf muscles, and lead to a fibroid thickening in the muscles—both conditions being likely to increase the contraction. On the other hand, *division of the tendo Achillis* is followed by such satisfactory results that there is no reason to adopt a longer, more painful, and less certain method.

The operation is performed as follows. The limb is turned over upon its outer side and steadied upon a sandbag, and the surgeon introduces a tenotomy knife through the skin on one side of the tendo Achillis—for choice on the inner side. The tenotomy knife should be very sharp, with a cutting edge not more than half an inch long; the rest of the blade should be rounded, narrow, and blunt, so as to lie in the small skin puncture made by the cutting portion without increasing it. Authorities are not agreed whether this or any tendon should be divided by introducing the knife along the deeper surface of the tendon and cutting towards the skin, or by insinuating the knife between the skin and the tendon, and cutting towards the deeper structures. The objections urged against the former procedure, which is the one more often adopted, are of considerable importance. In the first place it is easy to include between the knife and the skin vessels or nerves, which must then be inevitably divided along with the tendon; in the second place, the surgeon, in his anxiety to avoid the inclusion of these structures between the knife and the tendon, is apt to puncture the latter, and to leave some fibres undivided—an occurrence which would render the whole operation nugatory; in the third place, when the last fibres are divided, and the tendon gives way suddenly under the knife, the latter is apt to be thrust through the skin, and thus to convert a subcutaneous operation into an open one. As a matter of fact, many surgeons employ two knives with the view of avoiding the latter accident; the first is sharp-pointed and makes the track, and the other is blunt-pointed and is introduced along the track, after withdrawal of the first, and made to divide the tendon. This, however, is an unnecessary complication, the more so as it is not easy to push the blunt instrument along the track made by the sharp one. The chief objection urged against division of the tendon from without inwards is that the knife may divide important structures beneath as the tendon gives way; most of these structures lie in soft mobile tissues, however, and yield before the point of the knife, so that an accident of this kind very seldom occurs. We prefer to divide tendons by cutting from the skin surface downwards as it is a method by which one can be certain of not leaving any fibres undivided, whilst accidental enlargement of the skin opening is certainly avoided. It must be confessed, however, that enlargement of the skin wound is nowadays of little consequence ; at the same time it is best avoided, because the scar in the skin may become adherent to the cicatricial tissue between

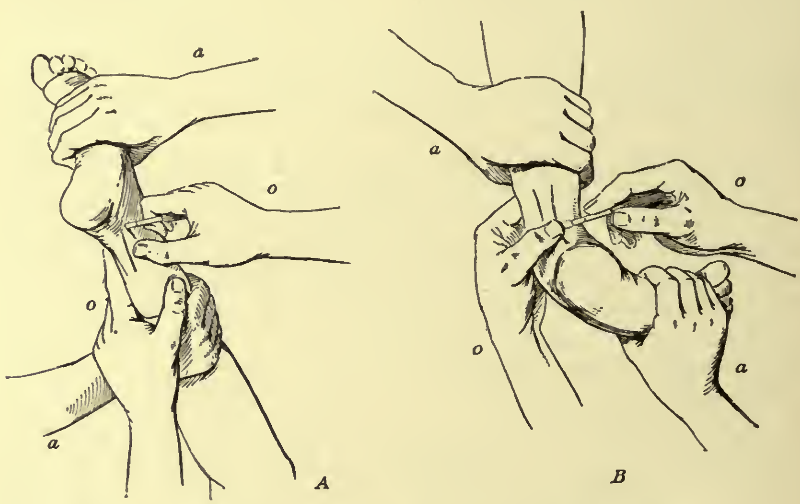


FIG. 102.—THE METHODS OF DIVIDING THE TENDO ACHILLIS SUBCUTANEOUSLY.

A. Division of the tendon from its deep surface towards the skin. The tenotomy knife is here introduced on the outer side at right angles to the skin, and is thrust across in front of the anterior surface of the tendon until its point is just beneath the skin on the inner side, where the surgeon notes its position with the left forefinger. In the drawing the assistant is in the act of making the tendon tense for the surgeon to divide it. It is more usual to introduce the knife from the inner side.

B. Division of the tendon from its superficial surface towards the bone. This is the method we prefer and have described in the text. In the drawing the point of the tenotome is shown as it is being insinuated between the skin and the tendon ; the surgeon notes its progress beneath the skin by means of the left thumb or forefinger. The parts are represented as being fully relaxed by the assistant in order to facilitate the passage of the tenotome across the back of the tendon.

In both drawings the surgeon's hands are denoted by the letters *o*, *o*, while those of the assistant are marked *a*, *a*. (*After Hoffa.*)

the divided ends of the tendon, and thus hamper the movements of the latter.

In division of the tendo Achillis, the knife should be introduced on the inner side of the tendon, about half an inch beyond its margin and about an inch above its insertion into the os calcis ; the blade should lie flatwise on the tendon. In fat children it is not always easy to define the edge of the tendon, and in them it is best to make the puncture about midway between the inner border of the tibia, which can always be felt, and the back of the leg. The foot is given in charge of an assistant who makes the tendon prominent by dorsi-flexing the foot whilst the puncture in the skin is being made ; as soon as this has been done, however, the tendon is relaxed by depressing the front of the foot in order to enable the surgeon to insinuate his knife more readily between it and the skin. The surgeon ascertains the progress of his knife as he insinuates it between the skin and the back of the tendon by means of his left fore-finger, and makes sure that no tendinous fibres are left between the knife and the skin (see Fig. 102). When the point has been passed well across to the opposite border of the tendon, the cutting edge is turned forward, and then the

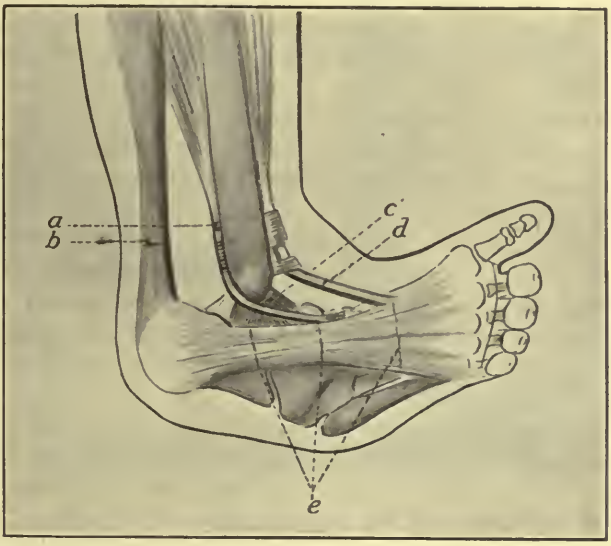


FIG. 103.—DIAGRAM SHOWING THE STRUCTURES NEEDING DIVISION IN TALIPES EQUINO-VARUS. (*a*) Tibialis posticus tendon. (*b*) Tendo Achillis. (*c*) Anterior portion of the deltoid ligament. (*d*) Tibialis anticus tendon. (*e*) Plantar fascia.

assistant puts the tendon firmly upon the stretch once more whilst the surgeon presses the knife against it and divides it with a steady, light sawing movement ; when the division is complete, the tendon gives way suddenly and a gap appears between the divided ends. Before withdrawing his knife, the surgeon should ascertain with his left fore-finger that there are no other tight structures requiring division ; sometimes the sheath of the tendon is also contracted and requires to be nicked. The principal reason for dividing the tendo Achillis at the spot recommended, namely an inch above its insertion into the os calcis, is that division at a lower point is not always satisfactory, because a series of tendinous slips are often given off at about that spot, to be inserted into the upper part of the os calcis, and proper relaxation of the tendon will not occur if they escape division. When the tendon has been divided, the foot should be forcibly dorsi-flexed two or three times, so as to stretch or tear through any other tight bands.

It is rarely that any *accidents* happen during the performance of this small operation. There may be bleeding from division of the short saphena vein, but this soon stops with light pressure. Puncture of the posterior tibial artery is extremely rare; should it occur, the best plan is to enlarge the skin incision, and expose and tie the divided ends. Some surgeons, however, apply firm pressure by means of a pad over the bleeding vessel in the first instance, and then adopt appropriate treatment later should a false aneurysm form. At the same time one need not cut down, merely because arterial blood spouts from the wound when the foot is moved; this may come from some small vessel, and will be arrested by the application of a pad and bandage. Should the wound in the skin be made too large by an accidental slip of the knife, its edges should be brought together with a stitch or two. The disadvantage of a large skin incision nowadays is not the risk of sepsis, but the possibility of adhesion of the scar to the new material thrown out between the ends of the tendon.

After-treatment.—The next point that arises is whether the foot should be put up in the over-corrected position at once or whether it should be left for a few days in its faulty position until a certain amount of reparative material has been thrown out between the divided ends of the tendon. The answer to this question depends upon the degree of deformity present.

In the milder cases, in which the gap left after tenotomy is less than two inches, the foot may be put up at once at right angles upon a suitable splint, such as the one already described (see Fig. 100). A small pad of gauze is fixed over the puncture with collodion, and care must be taken that the bandage fastening the limb to the splint does not press upon the gap between the divided ends, lest the formation of plastic material between the ends be interfered with. From the second day onwards the deformity is gradually over-corrected by slowly increasing the dorsal flexion of the foot until, in about a week, its extreme limit is reached. The foot is then fixed in plaster of Paris in this over-corrected position for another fortnight.

In three weeks from the operation the splint or plaster of Paris casing should be abandoned, and the limb massaged, while the patient is encouraged to carry out exercises designed to develop the muscles that are at fault. It is of special value to make the patient perform active movements against resistance which is gradually increased as the muscular power improves. By this time the uniting material will be sufficiently firm to connect the ends of the tendons; it is, however, not yet strong, but the patient may be allowed to walk about, provided that he walks on the flat of the foot and does not put much strain upon the tendon.

At a later stage the following arrangement will be found of value. A piece of wood of suitable size and thickness, long enough to extend from the heel to at least three inches beyond the tips of the toes, is cut to the shape of the foot. A piece of strapping, between two and three inches broad, and sufficiently long to reach from the middle of the thigh to the toes and then twice the length of the splint, is applied first to the upper surface of the splint, beginning near its anterior extremity, carried along the upper surface, round the posterior edge, and then along the lower

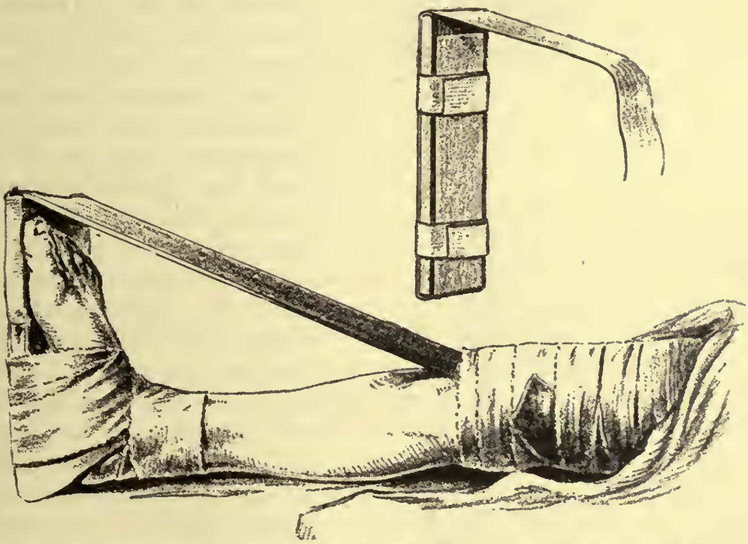


FIG. 104.—SAYRE'S APPARATUS FOR USE AFTER TENOTOMY OF THE TENDO ACHILLIS. The method of application is given sufficiently in detail in the text. The smaller sketch above is to illustrate the method of fastening the strapping to the foot-piece of the splint; it will be seen that it commences on the upper surface of the splint near its anterior margin, runs backwards along the upper surface, down round the posterior edge and finally runs forward along the under surface and round the anterior margin of the splint, where it terminates in a long free end which is shown applied to the thigh in the larger drawing. The length of the foot-piece varies; the more leverage it is desired to exert the further should it project beyond the toes.

surface and over the anterior edge again. This part of the strapping is then bound firmly to the splint by two or three transverse pieces of strapping (see Fig. 104). The splint thus prepared is padded, and fastened at the heel, sandalwise, by a broad strip of strapping passing around the instep and the posterior end of the splint; the splint is then secured to the foot by a bandage. The long end of the strapping which hangs over from the front of the splint is now applied along the front of the thigh, the foot meanwhile being held at right angles and the knee fully extended. The strapping is fastened by a bandage commencing just below the patella and carried up to the centre of the thigh. The free end of the strapping is turned down over the upper edge of the bandage, and the latter is carried downwards over it; in this way the strapping and the bandage are firmly fastened to the skin of the thigh. Should the strapping slip, as it generally does after two or three days, a second bandage applied over the old one and carried down rather further below the patella will keep it taut. The patient should be encouraged to walk wearing this apparatus; leverage is exerted upon the ankle joint as the patient walks, as the splint is longer than the foot, and the latter is bent far more effectually than if a boot were worn. The apparatus leaves the calf muscles free, and massage can be applied to them; it generally requires to be renewed about once a week.

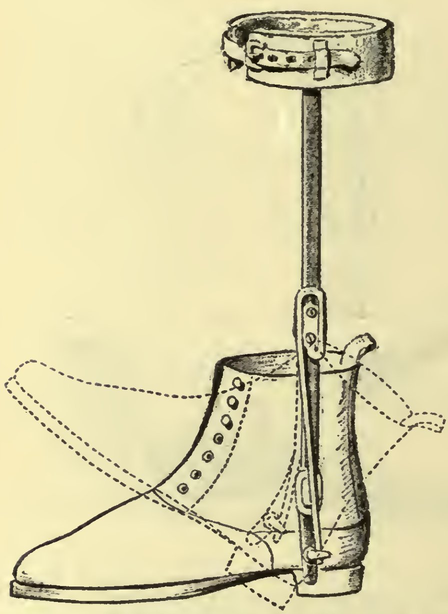


Fig. 105.—Boot for use after Tenotomy of the Tendo Achillis. The dotted line shows the position the boot tends to assume when the foot is off the ground; it thus continuously stretches the tendo Achillis. The boot should be made a good deal longer than the foot, and it should have a stop at the ankle-joint hinge to prevent the toes being pointed. (*Hoffa.*)

After about six weeks, more vigorous exercises should be commenced and carried out while the patient is wearing the splint just described. The following is of considerable value. The patient stands upright, the heels together, and the soles flat on the ground, and he then sinks downward, flexing the knees and hips until he is able to touch the ground with the tips of the fingers, when he again resumes the upright position. This should be done a dozen times in succession, and repeated several times during the day. At the same time massage and galvanism should be applied to the calf muscles. After about eight weeks from the operation it is well to employ a surgical boot, furnished with lateral irons attached to a band passing around the upper part of the leg, and made with a hinge opposite the ankle joint, fitted with a stop to prevent the foot being plantar-flexed beyond the right angle. It is well to have the sole of this boot made somewhat longer than the foot, for it then acts in a manner similar to the splint described above, and exerts a greater leverage than if it were the exact length of the foot. This boot is more sightly and convenient than the splint, and may with advantage be fitted with a spring which tends to keep the toes raised and the heel depressed (see Fig. 105); this is especially necessary when the calf muscles were much contracted prior to tenotomy.

In the more severe cases, in which there is an interval of two inches or more between the divided ends of the tendon when the foot is fully plantar-flexed, the uniting medium between the cut ends would probably be thin and soft if the deformity were corrected immediately, and there would certainly be a risk of imperfect union; in other words, a condition of talipes calcaneus might be substituted for that of equinus. Under these circumstances, therefore, the limb should be put on a splint in the uncorrected position and left for three days, so as to allow plastic material to be poured out between the divided ends. On the third day a slight correction of the position may be made, and a slight further correction is made every day until the foot has been brought to a right angle at the end of a week or ten days. In another week or ten days this is increased up to the extreme limit of dorsal flexion, so that the deformity is fully over-corrected. A plaster of Paris casing is then applied for three weeks, after which the Sayre's apparatus (Fig. 104), massage and exercises may be employed, just as in the milder cases.

In these cases also a surgical boot should be substituted for the Sayre's apparatus after the latter has been worn for a month or six weeks, and if these precautions be followed, the uniting material between the cut ends of the tendo Achillis will be as broad and firm as it is in the milder cases, and the limb will be thoroughly useful.

When all the muscles that produce dorsi-flexion of the foot are paralysed and do not show any sign of recovery after division of the tendo Achillis and correction of the equinus, there will be a continual tendency for the toes to drop and the equinus to recur. This must be guarded against either by making the patient wear a surgical boot (*vide supra*) indefinitely or by transplantation or grafting of the tendon of a healthy muscle, such as the tibialis posticus, on to the front of the foot, so as to make it act as a dorsi-flexing agent. The subject of transplantation of muscles is dealt with in connection with the affections of muscles.

In the second group of cases, in which changes other than the shortening of the calf muscles occur, the secondary contractions must be remedied before the tendo Achillis is divided. The most important contraction is that of the plantar fascia, the dense central portion of which is most commonly affected.

Division of the plantar fascia should be practised and the foot unfolded some weeks before the tenotomy of the tendo Achillis is done. Should the latter structure be divided at the same time as the plantar fascia, it will be difficult to stretch the sole sufficiently, because the heel is not fixed and purchase cannot be taken from it; if the tendon be left undivided, a satisfactory *point d'appui* is obtained. The plantar fascia is divided by putting the sole of the foot firmly upon the stretch, and dividing all the contracted bands with a tenotomy knife as far back towards the heel as is convenient. The patient is anæsthetised, and special care is taken in the disinfection on account of the thick skin in this region; the anterior half of the foot is strongly abducted so as to make the fascia tense, whilst the tenotomy knife is introduced between the skin and the fascia about half an inch to one side of the most prominent tense band, and at about the same distance in front of the tuberosity of the os calcis. As soon as the point of the instrument is introduced through the skin, the pressure upon the sole is relaxed, and the knife is insinuated between the skin and the fascia with the blade held parallel to the surface. The surgeon should bear in mind that the fascia comes very close to the skin, and is often in intimate connection with it. After the point of the knife has been pushed well beyond the tight band, the fascia is put firmly upon the stretch once more, the cutting edge of the knife is turned towards it, and made to divide it. It will generally be found that fresh bands start into prominence after division of the first, and these must be divided methodically, either from the same puncture or from another more conveniently placed. After all the bands have been divided, the foot should be stretched, either with the hand alone or with a wrench. If the foot can be got quite straight, or rather into the over-corrected position, by the hand alone, it is better than using a wrench, as less damage is done to the tissues. In many cases, however, it is difficult to stretch the sole adequately with the hand alone, and in these cases Thomas's wrench is useful (see p. 352).

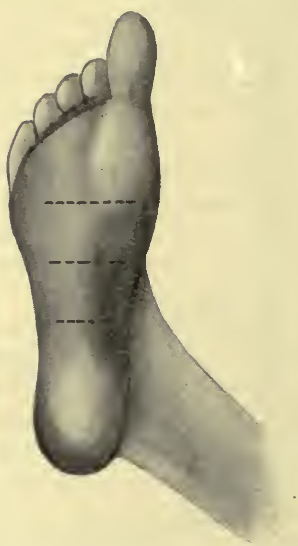


FIG. 106.—LINES OF INCISION FOR SUBCUTANEOUS DIVISION OF THE PLANTAR FASCIA.

After-treatment. — The foot should be brought into the over-corrected position, the small punctures dressed with gauze and collodion, and the metal splint (see p. 316) applied. In arranging the padding of the splint care must be taken that no undue pressure is exerted upon the heads of the metatarsals; the padding should be thicker in front of and behind the balls of the toes, so as to leave a depression into which they may sink. Should the tendo Achillis allow the foot to come to a right angle, the patient may be allowed to stand, wearing the splint, within a week after the operation; the standing position helps to promote the stretching of the sole. Should the contraction of the calf muscles be very great, however, this will not be possible. If there be much pain complained of after the operation, the splint should be taken off and the padding readjusted. This is an important matter, for serious trouble may result, should a slough form on the balls of the toes, as a permanently tender scar may be left.

In many cases it is necessary to repeat the division of the plantar fascia some three or four weeks after the first operation. In no case should the tendo Achillis be divided until the foot has been unfolded and the sole restored to its normal condition. The second operation should be practised further forward than the first, so as to divide individual slips of fascia which escaped division in the first operation, and which have become tense subsequently. After the surgeon is satisfied that the sole is sufficiently stretched (usually in six weeks after the treatment has been begun), the tendo Achillis may be divided, and the subsequent treatment carried out as for the first stage of the affection (see p. 326).

In the most severe group of talipes equinus two conditions are met with; either simple talipes equinus, in which the heel is drawn up and

A *B*

FIG. 107.—EXCISION OF THE ASTRAGALUS. *A* shows the incision on the inner, *B*, that on the outer side.

the sole of the foot is fairly straight, or very severe equinus combined with a certain amount of talipes cavus. We shall take the consideration of the former group first.

(*a*) It is well to commence the treatment with a free division of the plantar fascia, even although it may not be markedly contracted. In these bad cases simple division of the tendo Achillis is not sufficient to allow the foot to be brought into its proper position. This is due partly to contraction of the ligaments of the ankle joint, but mainly to the alterations which have occurred in the anterior part of the upper articular surface of the astragalus. In most cases the surgeon has to make a choice of some severe operative procedure, but, if the patient be young, a few weeks may be devoted with advantage to ascertaining whether, after a preliminary division of the plantar fascia, with subsequent division of the tendo Achillis and the posterior ligament of the ankle joint, continuous upward pressure upon the front of the foot by means of a splint will not lead to a cure. If the deformity be not overcome after a fair trial of these means (which are those described for the treatment of the second group of cases), the change in the shape of the astragalus must be remedied if possible. The operations at our disposal are excision of the astragalus, removal of a portion of the upper surface of that bone, excision of the ankle joint, or amputation.

Excision of the Astragalus.—In ordinary cases, when the nutrition of the parts is good, excision of the astragalus yields an excellent result, and is probably the best procedure. After this operation the foot is very useful, and the ankle joint is freely movable; the os calcis rises to some extent between the malleoli, and, when the operation is performed in young subjects, it is almost impossible, when they reach adult life, to tell that anything has been done.

Various incisions are used for the operation. It may be done by two vertical incisions, one on either side of the front of the ankle joint; that on the inner side commences about two inches above the internal malleolus, over the anterior border of the tibia, and runs downwards over the ankle to the dorsal surface of the scaphoid. This incision is carried down to the bone, but should avoid the tibialis anticus tendon, which is easily hooked out of the way. The second incision is made on the outer side; it commences about two inches above the tip of the external malleolus, and is carried downwards and forwards parallel with the inner incision to a point opposite the termination of the latter (see Fig. 107). The structures over the front of the ankle joint are separated by a periosteum detacher, and a copper spatula is passed beneath the bridge of soft tissues thus raised, which contains all the tendons, vessels, and nerves. These are pulled well forwards and protected against injury by the spatula. The lateral and anterior ligaments of the ankle joint are now divided and the astragalo-scaphoid articulation is opened. The strong calcaneo-astragaloid ligament is next divided, and then the astragalus is seized by strong forceps and gradually pulled forwards and to one side, and any resisting structure divided. At the posterior part of the bone the tendon of the flexor longus pollicis must be separated from its groove with a periosteum detacher.

A simpler method is by means of a single long incision, commencing just behind the fibula, $2\frac{1}{2}$ inches above the malleolus, and running vertically down as far as the tip of that structure, when it turns forwards along the outer aspect of the foot to the base of the fifth metatarsal. The flap is dissected up, the peronei tendons are turned out of their groove, the external lateral ligament of the ankle is divided, and the head of the astragalus disarticulated from the scaphoid. By inverting the foot forcibly, the strong inter-osseous ligament between the os calcis and the astragalus can be divided, and the latter bone freed from its remaining connections and removed.

After the astragalus has been removed, the foot is put up at a right angle upon a suitable splint. It is only in the most extreme cases that it becomes necessary to divide the tendo Achillis at the same time. In putting up the foot special care must be taken to prevent inversion, and the best apparatus is Croft's plaster of Paris splint, which is described in connection with fractures. Lateral poroplastic splints moulded to the foot while it is held in proper position are also useful, as are also the sterilised wire-netting splints recommended for fractures (see Vol. II.).

The chief point to remember in the after-treatment of excision of the astragalus is that there is a tendency to inversion of the foot which must be carefully guarded against. The splint should be kept on for six weeks, when the patient may be furnished with a suitable apparatus and allowed to walk. The apparatus should consist of a boot to which are attached lateral irons fastened to a band around the upper part of the leg and furnished with hinges opposite the ankle joint (see Fig. 108). This boot should be worn for eight months or a year, when it will generally be found that the foot has become firm in its new position.

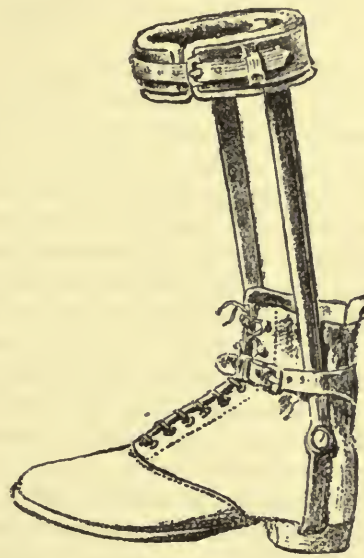


FIG. 108.—BOOT FOR USE AFTER EXCISION OF THE ASTRAGALUS. This is fitted with stout lateral leg-irons fastened into the heel below and furnished with a hinge-joint opposite the ankle. The chief object of the apparatus is to prevent inversion of the foot.

Partial Resection of the Astragalus.—When the deformity is not so great, it may suffice to expose the front of the astragalus by incisions similar to those just described, and to chip off enough bone from its upper and anterior surfaces, with a chisel or a gouge to enable the articular surface to pass beneath the malleolar arch, and then to bring the foot into the rectangular position, after division of the tendo Achillis. This operation, when feasible, is perhaps the best for adult cases, but in children excision of the astragalus gives such perfect results that it is preferable. If removal of a portion of the astragalus be practised, care must be taken to preserve the movements of the ankle joint by passive and active movements and massage. The movements should be begun within two days of the operation, and in the intervals the foot should be kept on a posterior splint with a hinged foot-piece which can be pushed up so as to over-correct the deformity.

Amputation.—Amputation is rarely called for, but when the condition is due to infantile paralysis, when there is extreme wasting of the parts, when the nutrition of the foot is markedly interfered with, when the latter is constantly subject to ulceration, and when in fact the foot would be useless even were it restored to its proper position, amputation will be far more satisfactory than an attempt to retain the foot and restore its functions by apparatus. Amputation of the leg at the seat of election will be the operation of choice if the quadriceps and the hamstrings are not paralysed ; if they are, it will be necessary to disarticulate at the knee-joint or amputate through the femoral condyles.

(*b*) In the second class of these severe cases of talipes equinus, those, namely, in which there is marked talipes cavus, the treatment appropriate for the latter condition must be employed also (*vide infra*).

TALIPES CAVUS.

Pes cavus is an acquired deformity usually due to infantile paralysis. It is due to a dropping of the front of the foot, with secondary contraction of the plantar fascia. When the weight is borne upon the sole, the patient generally suffers pain from stretching of the plantar fascia and the ligaments ; callosities and corns form over the metatarsal bones, and may cause great suffering.

Excision of a Wedge from the Tarsus.—Should division of the plantar fascia (see p. 329) and wrenching fail, it may become necessary to remove a portion of the tarsus, in order to bring the sole of the foot flat upon the ground, and this should be done and the foot brought straight before the tendo Achillis is divided. The operation is performed through horizontal incisions along the inner and outer sides of the foot, at about the level of the scaphoid bone ; these are carried down to the bone, all the soft structures being peeled off the plantar and dorsal surfaces of the tarsus with a periosteum detacher. The soft parts are held aside by copper spatulæ introduced between them and the bones, and a wedge-shaped portion is cut from the tarsus by means of a saw insinuated between the spatulæ and the bone. The portion of bone removed should have its base directed towards the dorsum of the foot, and its apex towards the sole. The bones should be removed without any regard to their articulations ; the block excised generally consists of the head of the astragalus and portions of the scaphoid and cuboid. When the dimensions of the wedge have been judged accurately the foot can be brought into position ; further portions of the bones may be removed with a chisel should there be any difficulty in doing this.

Division of the plantar fascia and wrenching of the foot should be practised before the soft parts are separated from the bones, as it would be impossible to do this after the bones have been divided, and, therefore, more bone than is actually necessary would have to be taken away. The size of the wedge should be such as to allow the patient to walk upon the under surfaces instead of the ends of the metatarsal bones. It should not be so great as to obliterate the arch of the foot entirely, and it is well to make the wedge rather small in the first place, and then, if necessary, to remove a second slice, the thickness of which can be estimated accurately after the wedge has been removed.

The bleeding is arrested, the wound stitched up without a drainage tube, antiseptic dressings applied, and the foot put into proper position. A back splint with a footpiece at right angles is put on for about six weeks, until bony union has occurred. Then the tendo Achillis may be divided, and, if necessary, the posterior ligaments of the ankle also may be cut, so as to enable the foot to be brought up to a right angle in the first instance, and, subsequently, to an acute angle. In another three weeks the patient may be allowed to walk, and the treatment recommended for the milder cases of talipes equinus is then carried out (see p. 326).

TALIPES CALCANEUS.

As a congenital deformity this is rare. It usually occurs as the result of infantile paralysis of the calf muscles The congenital form is often associated with an absence of the fibula, or some similar arrest of development of the leg. When the fibula is absent, there is usually talipes calcaneo-valgus. Some degree of talipes calcaneus is often seen in the newly-born child, but it rarely requires attention and nearly always recovers spontaneously. In the paralytic form, the front part of the foot is drawn up by the unbalanced action of the muscles on the front of the leg ; the heel is depressed, so that in bad cases the upper part of the instep may lie in contact with the anterior surface of the leg, whilst the patient walks upon the extreme point of the heel. There is a tendency to some valgus deformity as well.

TREATMENT.—As in all the other paralytic cases, it is easy to get the foot in position without using force as long as the affection is in its early stages ; in these cases the treatment must be directed to retaining the foot in proper position, whilst efforts are made to maintain or restore the functions of the paralysed muscles.

By Massage and Apparatus.—To meet the first indication, a suitable splint should be applied ; in children we prefer the simple metal splint with the connecting stout copper wire, already described (see Fig. 100), which can be applied by the nurse. The splint should be taken off several times a day and massage should be applied to the calf muscles, followed by manipulations designed to stretch the muscles on the front of the leg. The Faradic current may be beneficial, whilst at night, and in the intervals between the application of the massage and galvanism, the splint should be re-applied. If these measures be carefully carried out in the early stages, tenotomy will seldom be necessary.

The subsequent treatment will depend upon the condition of the muscles—*i.e.* the extent and distribution of the paralysis,—and also on the willingness of the parents to submit the child to operative procedures. Thus the paralysis of the calf muscles may be only slight, but the parents may be averse to operation; or the paralysis, though marked, may not be complete. On the other hand the paralysis of the calf muscles may be complete. This method is also admirably suited for the later stages of those cases in which the paralysis of the calf muscles is only partial and there is good hope that recovery may occur provided that the weak muscles can be exercised gradually and are not submitted to undue strain. It is, moreover, the only procedure that can be adopted when operative measures are refused or fail.

As the child learns to walk, he should be fitted with lateral leg-irons grasping the limb just above and below the knee, and fastened below into the heel of the boot. There should also be a hinge-joint opposite the knee and the ankle; the latter should have a stop so as to prevent the foot being bent upwards beyond a right angle, and it is well also to have an artificial tendo Achillis fitted to the apparatus (see Fig. 109); the most convenient arrangement is a rubber spring from the heel of the boot to the band below the knee. When the foot is lifted from the ground, the heel is drawn up by the spring, and when the foot is brought to the ground, the weight of the body stretches the rubber and allows the foot to come to a right angle, where it is stopped by the hinge arrangement. When the patient is not walking, it is well to take off this apparatus, which is often heavy for an enfeebled limb, and to employ massage, electricity and douching, and the lighter splint already mentioned (*vide supra*).

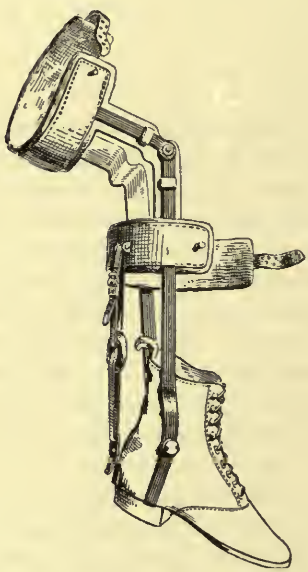


FIG. 109.—BOOT FOR USE IN TALIPES CALCANEUS. The india-rubber spring behind takes the place of the faulty calf muscles. The boot is often fitted with a stop at the hinge joint opposite the ankle so as to prevent the toes being raised unduly. (*Hoffa.*)

By shortening the Tendo Achillis.—When electrical examination shows that there is still some healthy muscular tissue left in the calf muscles, the usefulness of the limb may be promoted by shortening the tendo Achillis. The operations for shortening the tendo Achillis are not always satisfactory, as the union between the divided ends may stretch after a time and allow the deformity to be reproduced. On this account simple transverse division and resection of a portion of the tendon are not always sufficient. In order to obtain a successful result, the operation should be more elaborate and designed to obtain a broader and firmer uniting surface, or the tendon need not be divided at all, but its point of insertion into the os calcis may be changed.

Plastic Operations upon the Tendo Achillis.—The tendo Achillis is exposed by turning up a flap, made by carrying an incision from a point about half an inch to one side of the tendon, and at a similar distance above the proposed point of division, downwards, to an inch below the proposed point of division, and then bringing it across the tendon, and up to a point on the opposite side of the tendon corresponding to its starting point (see Fig. 110). The object of making a flap in order to expose the tendon is that the line of union of the flap shall not correspond anywhere to the line of division of the tendon, and therefore there will be

FIG. 110.—FLAP METHOD OF EXPOSING THE TENDO ACHILLIS. The line of section for the plastic operation for shortening the tendon is also shown, and it can be seen that there is no likelihood of the cicatrix in the skin becoming united to that in the tendon.

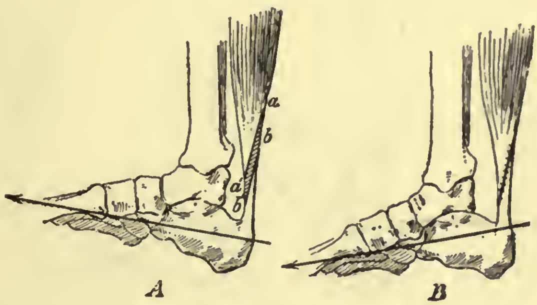


FIG. 111.—OBLIQUE SECTION FOR SHORTENING TENDONS. In *A* are shown the incisions, the upper one *aa'* commencing just below the muscular fibres; the portion *aa'b'b* between the two incisions is removed. In *B* this has been done, and the cut surfaces of the tendon have been sutured. Enough has been removed to raise the heel and point the toes somewhat.

no risk of adhesion between the incision in the tendon and that in the skin. The method of shortening the tendon varies; there are two principal plans: to divide the tendon obliquely, so as to have a very broad surface for union, and to divide it in a ⅂-shaped manner. Occasionally it may be necessary to divide the tendons on the front of the ankle as a preliminary measure if they offer any obstacle to re-position of the limb.

Oblique Section of the Tendo Achillis.—The tendon is exposed in the manner just indicated, and then divided obliquely from above downwards and forwards (see Fig. 111). The incision through the tendon should be nearly two inches in length, and should commence close to, or even actually through, some of the muscular fibres. After the tendon has been divided, a sufficient portion of the lower part is removed by a second incision parallel to the first; the amount removed should be such that, when the oblique surfaces are brought into apposition, the foot is either at or slightly beyond a right angle to the leg. The foot is brought into position and the cut surfaces of the tendon are united by a continuous suture. Hæmorrhage is arrested, and the wound is sewn up without a drainage tube. A broad surface for union is thus obtained, and the result is usually fairly satisfactory if care be taken not to put any tension upon the tendon for some weeks afterwards.

⅂-shaped Section of the Tendo Achillis.—After turning up a flap as before, an incision is made in the tendon, commencing on one side, and running transversely across it as far as its centre. The knife is then turned downwards at a right angle to this incision, and the tendon is split vertically along the middle line for about a couple of inches. At the lower end of this incision the knife is turned transversely across the

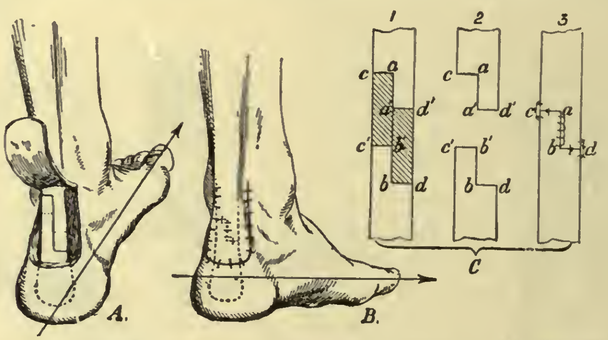


Fig. 112.—⅂-Shaped Section for Shortening Tendons. In *A* the tendon is seen exposed by raising a flap; the dark line shows the incision in the tendon, the dotted ones indicating the amount of tendon removed after the latter has been thus divided. In *B* the tendon has been shortened and sewn together; the toes are a little depressed as in the preceding figure. *C* shows diagrammatically the steps of the division of the tendon and the methods of suture. In (1) the line of incision in the tendon is *c, a, b, d*; when the two ends are separated, incisions along the dotted lines *a'd'* and *b'c'* are made to cut off the portions *acc'b'* and *d'a'bd* (shaded in the diagram.) This gives the tendon the shape and length represented in (2). The divided ends are then brought together and sutured as in (3). It is important to remember in cutting off the portions of tendon that *dd'* must be equal in length to *cc'*.

tendon, and directed towards the opposite side to that originally divided, and is made to divide the remaining half of the tendon (see Fig. 112). In this way, two flaps of tendon are made, and enough is cut from each flap to obtain the necessary shortening when the divided surfaces are brought into contact. A good practical rule is to make the vertical part of the incision in the tendon double the length of the portion that must be removed in order to bring the foot into position. The ends are stitched in accurate apposition with silk; details of the method of suture are given in connection with the affections of tendons. In some ways, this method is more satisfactory than the preceding one, as the union is a combination of a transverse with a vertical one, which is very strong, whereas in the other the union is oblique and may yield. Moreover, the ⅂-shaped division can be practised lower down, and need not involve the muscular fibres.

After-treatment.—Whichever be the method adopted, the foot must be kept in a position of equinus for at least six or eight weeks, so as to allow of sound union between the divided ends; even then great care must be taken not to put strain on it for fear of stretching the uniting material. The patient should not walk for six months after the operation, and, when walking is permitted, should be furnished with the apparatus fitted with a stop which prevents the joint being dorsi-flexed beyond a right angle (see p. 336). The calf should be massaged and douched daily, and the Faradic current applied to the muscles.

Transplantation of the Insertion of the Tendo Achillis.—In order to avoid the risk of the union of a divided tendon stretching subsequently, some surgeons alter the bony attachment of the tendo Achillis to the os calcis. When the nutrition of the leg is faulty, and when, therefore, the union in such a slightly vascular structure as tendon might be imperfect, a satisfactory result may be obtained by altering the point of insertion of the tendo Achillis into the os calcis. The objection to this plan is, however, that the amount of shortening obtained by its means is comparatively limited, and the method is only of real value when the degree of calcaneus is very moderate.

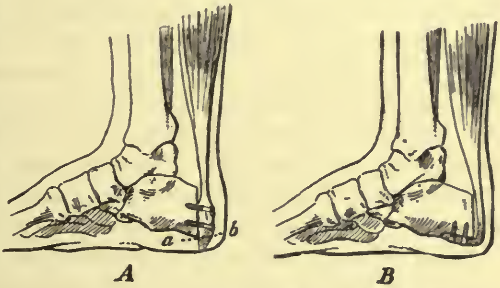


FIG. 113.—TRANSPLANTATION OF THE TENDO ACHILLIS. This is a diagrammatic representation of the two operations described in the text. In *A* the slice of the os calcis is drawn down as low as possible and fixed in position with screws: the portion below the dotted line *ab* is then sawn off. In *B* further shortening is obtained by turning the slice of bone round at right angles, making a raw surface with a chisel or saw on the under aspect of the os calcis and fastening the slice of bone down to it.

Two operations have been recommended (see Fig. 113); in the first, a flap with its convexity upwards is raised over the heel, and dissected downwards so as to expose the whole of the posterior part of the os calcis. A saw is then applied transversely to the upper surface of the bone immediately in front of the tendon, and, by a vertical cut, a thin slice of the bone, with the attachment of the tendo Achillis to it, is sawn off. This slice of bone is pulled down until the insertion of the tendon is as low as may be necessary, or as low as possible, and the bone is fixed into its new position by two or three small tacks. The projecting lower portion of the slice of bone is then cut off level with the under surface of the os calcis.

When the deformity is extreme, it has been advised that the upper part of the bone thus sawn off should be turned round at a right angle and applied to a raw surface made by a chisel on the under surface of the os calcis; this brings down the insertion of the tendon to the lowest possible point. The results of this plan, however, do not seem to be as satisfactory as those of the preceding one.

After-treatment.—After the operation the wound is stitched up without a drainage tube and the foot is put up on a splint with the toes markedly pointed for about six weeks until bony union is complete, when the patient may walk about wearing the boot already described (see p. 336).

By Muscle and Tendon Transplantation.—This subject has attracted considerable attention, and may well be considered here, since it was for the relief of a case of paralytic talipes calcaneus that Nicoladoni performed the first operation of the kind in 1882. Since that time the principle has been applied to various paralytic deformities with enough success to warrant the procedure taking a permanent place in the surgery of paralysis.

The method has for its object the assumption of the functions of a paralysed muscle by a neighbouring healthy one. This may be done either by the attachment of the tendon of a paralysed muscle to part or the whole of a tendon of a neighbouring healthy muscle or by transplanting the insertion of a healthy muscle to the insertion of a paralysed one. Thus, in the case of talipes calcaneus the tendo Achillis may be attached to the peroneus longus when the latter muscle is not paralysed, and thereby the healthy peroneus is made to assume the functions of the paralysed calf-muscles. The peroneus longus might also be transplanted directly into the os calcis if desired. The rectification of the deformity is thus effected by muscular agency and not by splints.

The method should not be practised until it is certain that no further recovery of function will occur in the affected muscle or group of muscles; therefore at least two years should be allowed to elapse between the onset of the paralysis and the performance of the operation, for extensive recovery may occur under suitable conditions even in the most unpromising cases. During this time also it is essential that the limb should be in such a position as to relieve the paralysed muscles of all undue strain.

Asepsis is essential for success; it is important to choose muscles that will undergo the least alteration in direction in the process of transplantation. The incision must be so arranged that the line of union in the tendon does not coincide anywhere with that in the skin. The limb should be put up so that there is no strain put upon the union between the anastomosed tendons; finally the transplanted muscle has to be exercised gradually to perform its new functions and to bear the new strains thrown upon it. Too much must not be expected from this method; when properly performed in suitable cases, however, so much improvement may follow that splints or special apparatus may be dispensed with.

In deciding upon the particular form of transplantation that he will adopt, the surgeon must be guided by the extent and distribution of the paralysis, but he should always try to work with muscles whose functions are similar, although this is not essential, as a muscle can be re-educated and extensors can quite well become flexors. He should never transplant a muscle or its tendon into such a situation that it cannot work to advantage, and finally he should not set one muscle the task of performing two opposite movements as would be the case if the tendo Achillis were split and one half were anastomosed to a paralysed tibialis anticus.

The choice of operations is very large : we need only indicate the most common ones, as each case must be treated on its merits. When the dorsal abductors are paralysed and the foot falls into a varus position, the tendon of the tibialis anticus may be made to pass beneath the extensors and fastened to the insertion of the peroneus tertius. A paralysed tibialis anticus may be replaced by a healthy extensor hallucis, and paralysis of the calf muscles may be treated by inserting the tendon of the peroneus longus into the tendo Achillis. Sometimes the tendon of the peroneus brevis is made to pass between the tendo Achillis and the tibia to be inserted into the tendon of the tibialis posticus.

There is little to say as to the steps of the operation ; tendon grafting is dealt with elsewhere (see Vol. II.). The main points to be attended to are :

(1) To unite the tendons so that there is no slack when the limb is in the over-corrected position.

(2) To secure as firm and as large a surface of union as possible, by an oblique section, or by some of the other methods recommended for tendon suture. When the tendon of the paralysed muscle is very small it is well to implant the tendon of the healthy one into or beneath the periosteum ; some surgeons bore holes in the bone and thus tie down the tendon. These precautions are necessary to prevent the union stretching or giving way subsequently, as it might do were an ordinary end-to-end union practised.

(3) Sometimes a single large incision will do, *e.g.* when two parallel muscles are operated upon ; sometimes a flap is necessary and sometimes two separate incisions are wanted, *e.g.* when a tendon has to be transplanted from one side of the foot to the other. The mobility of the tendon does not appear to be materially interfered with, even after it has been removed from its sheath and passed for a considerable distance through connective tissue, so long as its direction is such that it can act to advantage.

(4) After the operation, the limb is put up in the slightly over-corrected position, and when the wound has healed, a plaster casing is applied and left on for a month or more in order to insure firm union. Some light apparatus designed to prevent stretching of the transplanted muscle should be worn for at least another six months, and during this time massage and exercises must be employed to strengthen the transplanted muscle. In seven or eight months from the time of operation all apparatus may be dispensed with, and the patient may walk freely. It is advisable, however, to persevere with the exercises for at least six months longer.

Arthrodesis.—This term implies the artificial production of anchylosis in a joint by removing the articular cartilage. It is useful in those flail-like conditions of the ankle-joint when all the muscles in connection with it are paralysed, as the patient is thereby enabled to bear his weight firmly upon the foot, whereas otherwise no apparatus would fix the joint without causing serious pressure sores. It is done at the knee joint in some cases in which the paralysis is so wide-spread that the joint is flail-like ; it then gives the patient a firm support in place of a limb that is too feeble to bear apparatus. It is also useful in the case of the astragalo-scaphoid joint in bad cases of valgus.

The steps of the operation need not be described in detail here. The particular joint is opened freely by a suitable incision and all the articular cartilage is removed by a gouge or a sharp cutting rugine. The wound is then closed and the limb is put up in the required position and kept there for six weeks or more, when firm union should have occurred between the articular surfaces. It is important to remove the cartilage freely.

TALIPES VALGUS.

As a congenital affection, this condition is comparatively rare ; when it does occur it is most frequently associated with absence of the fibula. Even as an acquired affection the deformity is not very common ; it then most frequently results from infantile paralysis, and the deformity is produced by the unbalanced action of the peronei muscles, the tibials and the extensors of the foot being paralysed. It may also occur in connection with rickety deformities of the leg, or faulty union of fractures of the tibia.

PATHOLOGICAL CHANGES.—The principal alterations in the foot are stretching of the internal lateral ligament of the ankle joint with a corresponding contraction of the external lateral ligament, and to a lesser degree, stretching of some of the other ligaments on the inner side of the foot. In the early stage it is easy to bring the foot into its normal position by manipulations alone, but in the later stages the ligaments and muscles, especially the peronei, become contracted, and will require division before the foot can be restored to position. In severe or long-standing cases, alteration in the shape of the bones also occurs, and forms a further obstacle to the reduction of the deformity.

TREATMENT.—In the early cases, in which the position of the foot can be rectified by the hand alone, the treatment should aim at preventing the occurrence of the deformity, and increasing the strength of the weakened muscles, so as to enable them to raise the inner border of the foot. This should be done by *manipulations* carried out by the nurse, who gradually inverts the foot, and brings it inwards at the mid-tarsal joint ; *massage* and *douching* of the muscles, particularly the tibials and extensors of the toes, and the *galvanic current* are also useful.

In the intervals between the massage and passive movements, the foot should be kept in the corrected position by means of a suitable *apparatus*. In the early stage, before the patient learns to walk, the metal splint already mentioned (see p. 316) is the most satisfactory, but when the patient can walk he should wear an apparatus designed to prevent eversion of the foot. This consists of lateral leg irons, the outside one being particularly strong, jointed at the ankle, and hinged to the heel of the boot, which should be of thick leather, and should have the inner side of the sole and heel slightly thicker than the outer (see Fig. 114). The heel should also extend further forwards than usual; in fact, the boot should be made much on the lines recommended for flat foot (see p. 306), for in these cases of talipes valgus a certain amount of flat foot is generally present, and must be corrected. In many cases it is well also to employ Whitman's springs (see p. 303). The boot should only be worn while walking, and should be removed as soon as the patient complains of being tired, or of the apparatus causing pain; the limb should then be massaged and douched, and the light metal splint put on.

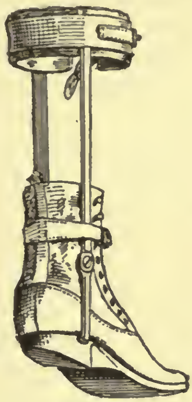


FIG. 114.—BOOT FOR USE IN TALIPES VALGUS. These are similar to those for use in flat foot, with the addition of lateral leg-irons, the outer one being especially stout.
The drawing is a view of the boot from the inner side, and shows the obliquity of the heel and the filling up of the arch of the instep. Compare Fig. 96.

When the tibialis posticus is completely paralysed, its tendon may be joined either to that of the peroneus longus or to a slip divided from the tendo Achillis (see p. 341), and thus the support to the inner border and arch of the foot may be strengthened.

In advanced cases in which there is marked shortening of the peronei tendons, it may be necessary to divide them and sometimes also to divide the external lateral ligament of the ankle joint. *Division of the peronei tendons* is done about an inch and a half above the tip of the external malleolus. The tenotomy knife is inserted between the tendons and the fibula; the edge of the peroneus longus can be made out easily, and the peroneus brevis comes into relief as soon as this is divided, and can also be cut. The short saphena vein may be wounded in this operation but this is not a matter of consequence. In paralytic cases, instead of merely dividing the peronei it is well to join the divided peroneus longus to the tibialis posticus (*vide supra*).

After the tendons have been cut, the foot should be put up in a position of slight adduction. In hospital patients it is best to put up the foot in plaster of Paris. Any co-existing flat foot must also be corrected and the arch of the instep well raised.

When there is sufficient union between the divided ends of the tendons, namely, after the lapse of about three weeks, treatment on the lines already laid down for the milder degrees of the deformity should be carried out (*vide supra*). In the case of a child not able to walk, massage of the weak muscles, with proper manipulations and fixation of the foot by splints in the intervals, should be employed ; when the child can walk, the apparatus above recommended should be used in addition to massage and electricity.

When the deformity is associated with some alteration of the bones, resulting either from rickets or from injury, the initial treatment must be directed to remedying the osseous deformity. Thus, in rickety cases the bones of the leg should be brought straight (see Curved Tibiæ) should the deformity be extreme. In traumatic valgus occurring after Pott's fracture, it may be necessary to restore the bones of the leg to their proper position. This matter is discussed in connection with Pott's fracture (see Vol. II.). The results of this operation are often very successful.

TALIPES EQUINO-VALGUS.

It is not uncommon for some equinus to be combined with talipes valgus. This deformity is perhaps more frequently congenital than acquired. The remarks about equino-varus may be applied equally to talipes equino-valgus. As in the treatment of equino-varus, the valgus deformity should be corrected before the tendo Achillis is divided.

TALIPES VARUS.

Pure talipes varus is exceedingly rare, the great majority of the cases being the condition spoken of as talipes equino-varus. True varus, however, may result from infantile paralysis, affecting only the peronei muscles and leaving the tibials and the anterior muscles of the leg unaffected. It may also result from cicatricial contraction, or from badly united fractures of the leg. The treatment of this affection is similar to that of the varus deformity in talipes equino-varus.

TALIPES EQUINO-VARUS

This form of club-foot is the most common and the most important of all those with which the surgeon has to deal. The foot is in a position of adduction, the inner side being shortened and drawn up, whilst there is a marked lateral flexion at the mid-tarsal joint, the anterior part of the foot being drawn inwards. Sometimes the displacement of the front of the foot is so marked that its inner border forms an acute angle at the mid-tarsal joint. Besides this deformity the heel is drawn up as the result of the shortening of the calf muscles. The vertical plane of the whole of the foot is altered, the under surface of the os calcis looking somewhat inwards instead of directly downwards

PATHOLOGICAL CHANGES.—The condition may be congenital or acquired. The *acquired* form may be due to infantile paralysis; to some spastic condition of the muscles, as in spastic paraplegia or hysteria; to injuries, such as dislocations or fractures about the ankle joint; to diseases of that articulation; or to cicatricial contraction in its neighbourhood. In the *congenital* form there is not only tightness of certain tendons, but also alterations in the other structures of the foot, particularly the ligaments and bones. The most marked change in the bones occurs at the junction of the neck with the body of the astragalus, the normal angle of which is profoundly altered; according to Parker, instead of being about 38° as in the normal fœtal astragalus, it may reach as much as 50°. Under normal conditions the obliquity of the neck of the astragalus diminishes as the child grows, so that the angle of inward deflection of the neck is a little over 10° in the adult; on the other hand, in equino-varus in the adult, it may still remain at about 50°. It is evident that the shape of the anterior part of the foot must be seriously altered by such a marked increase in this angle, and that there is a distinct obstacle to the reduction of the deformity in the osseous system itself.

As the result of the equinus position there is a further change in the astragalus. The greater part of the upper articular surface of the bone is uncovered, and the alterations described in speaking of talipes equinus occur as the result (see p. 320); at the same time, the portion which articulates with the tibio-fibular arch is narrower than it ought to be, and thus a certain amount of lateral displacement is allowed. As time goes on, changes also occur in the other tarsal bones, particularly the cuboid and scaphoid, but, although these may give rise to an additional obstacle to the reduction of the deformity, their influence is not nearly so great as that of the deformity in the astragalus. In advanced cases there is also a marked alteration in the bones of the leg, the ankle being rotated inwards as a whole, so that the external malleolus lies on a plane anterior to that of the internal, this condition being the opposite of the normal. These extreme changes are usually only reached, however, when the patient is allowed to attain adult life before an attempt is made to restore the foot to its proper position.

Besides the alterations in the bones there are also certain changes in the ligaments of the tarsus; those on the dorsum and the outer surface of the foot become elongated, while those on the inner side are shortened and thickened. According to Parker the most important changes take place in the ligaments around the astragalo-scaphoid joint, in the anterior portion of the internal lateral ligament of the ankle joint, and in the inferior calcaneo-astragaloid ligaments. In the early stages of the deformity these ligaments interfere more seriously with its reduction than does the altered shape of the neck of the astragalus itself, for in infants in whom the bones are cartilaginous, it is comparatively easy to bend them into a new position, whilst the ligaments are tight and thickened, and are not stretched so readily.

The muscles are not contracted in the early stages, and there is usually little difficulty in reducing the deformity in an infant a few weeks old ; if, however, the deformity be allowed to continue, they become tight, and reposition of the foot cannot be carried out until after division of their tendons. The muscles chiefly affected are the tibialis anticus and posticus, the gastrocnemius, and in some cases the flexor longus digitorum.

TREATMENT.—The surgeon has to take into consideration the alterations in the bones, ligaments and muscles ; the shortening of the plantar fascia ; and finally, the tightness of the skin upon the inner border of the foot. The contraction of the plantar fascia and the tightness of the skin are points of special importance, for the shortening of the inner border of the foot and the increase of the plantar arch will not be remedied unless means be taken to rectify these. In advanced cases also, changes occur from pressure upon parts that are not intended to bear pressure. Thus, callosities develop on the outer border of the foot, and, in severe cases, on the outer side of the dorsum. Beneath the callosities are bursæ, which are liable to attacks of inflammation and suppuration and may cause considerable pain and give rise to further thickening and matting together of the soft parts in their neighbourhood.

From the point of view of treatment, the cases of equino-varus coming under the notice of the surgeon may be divided into two main groups : those in which the deformity can be reduced readily by manipulation, viz., those in which there are no resisting structures requiring division ; and those in which there are one or more resisting structures, and in which, therefore, some form of operative procedure is required to restore the foot to position. This second group may be further sub-divided into two classes, namely those in which the obstacle to reduction is formed by shortened muscles, fasciæ, or ligaments, and those in which the obstacle is due essentially to some permanent alteration in the shape of the bones.

Treatment of Cases in which the Deformity can be reduced by Manipulation alone.—It is mainly the congenital cases seen within the first few weeks after birth which come under this heading ; in them the deformity may be cured without the necessity for any operative procedure if careful treatment be begun at once and carried out perseveringly. In this early stage the deformity is due to weakness of the muscles and to alterations in the shape of the bones. The treatment, therefore, should consist of manipulations designed to prevent shortening of the muscles, and to stretch any structures that are unduly tight ; besides this, some form of retentive apparatus will be required to keep the foot in position in the intervals between the manipulations. Both these measures tend to restore the bones gradually to their proper shape. Massage, and, in some cases, electricity should also be employed to increase the nutrition of the muscles; massage is more useful than electricity, which is only useful when the case is of paralytic origin and which has the objection that it may frighten the child. Unless this treatment be begun at the earliest possible period, operative measures must precede it, since tight structures will have to be divided. Hence treatment should be commenced immediately the condition is noticed, which is usually within a few days after birth. Under these circumstances, the outlook is very favourable, and practically the entire course of treatment can be carried out by the mother or an intelligent nurse.

Manipulations.—The manipulations are simple, but should be carried out regularly and for a long time. They consist essentially in abduction of the anterior part of the foot at the medio-tarsal joint, and eversion and dorsi-flexion of the foot as a whole. They should be carried out gently, so as not to frighten the child or to produce pain; if pain be caused, spasm of the muscles is set up, and this offers an obstacle to the manipulations. If, on the other hand, the manipulations be carried out gently and in a coaxing manner, the child becomes accustomed to them and does not resent them.

The front part of the foot should be grasped with the right hand while the leg is steadied with the left which embraces it just above the ankle joint. The metatarsus is then gradually carried outwards, until the inner border of the foot is quite straight. The right hand should next be slipped up a little more towards the heel, so as to grasp the whole foot, the toes lying between the ball of the thumb and the little finger. The entire foot is then gradually everted until the sole looks rather outwards, and the foot is dorsi-flexed at the ankle joint, while eversion is maintained. The essential points in this procedure are to unfold the anterior part of the foot, to overcome the inversion of the foot as a whole, and to dorsi-flex the foot at the ankle joint. It is of extreme importance to remember that it is not enough to produce eversion of the anterior half of the foot alone—that part, namely, in front of the mid-tarsal joint. This point is often overlooked, not only in these early cases, but in those of every description, and the result is that, while after prolonged treatment the equinus and the faulty position of the front half of the foot have been overcome, the under surface of the os calcis looks inwards instead of directly downwards. When the foot is everted, the os calcis should be everted as well as the anterior part of the foot.

After the foot has been brought into position by these manipulations, it should be held there with the right hand for five or ten minutes, whilst the leg is gently rubbed, and the muscles of the calf and front of the leg are kneaded with the left. These manipulations and the accompanying massage should be repeated three or four times a day, and in the intervals the foot should be fixed in a splint, so as to prevent recurrence of the deformity.

Apparatus.—The most satisfactory splint for infants is the metal one already described (see Fig. 100) which should be firmly fastened on the limb with bandages while the foot is in its faulty position; then one portion of the splint is grasped with each hand, and the foot is slowly brought into a position of eversion and dorsi-flexion, *i.e.* over-correction. The copper bar yields to the pressure of the hand but is stout enough to prevent recurrence of the deformity from muscular action. The splint should be worn continuously night and day, and should only be removed to allow of the manipulations and massage already described.

At the end of three or four months from the commencement of treatment carried out methodically in this manner, the foot will retain its position, even if the splint be left off for some little time; the splint however, should be continued for at least two or three years after the deformity has been corrected. It must be remembered that, although the resistance of the muscles and the ligaments may be overcome quickly, it takes a long time for the bones which are altered in direction to be moulded to their new position, so that, if the retentive apparatus be left off too soon, the deformity is almost certain to recur. When the child begins to walk, a Scarpa's shoe (see p. 354) will be more convenient and satisfactory than the arrangement just described.

So far, we have been speaking only of cases for which an intelligent nurse can be obtained, who can give the child constant attention,—conditions which do not exist among the poor. When there is difficulty in obtaining proper attendance, or when the parents are too stupid to carry out the treatment properly, the best procedure is to put the foot up in plaster of Paris in the over-corrected position quite early. This is, however, not so good a method as the one recommended above, as the plaster of Paris encloses the leg, and, therefore, the nutrition of the muscles is interfered with to some extent. The plaster also gets soiled by urine, and gets loose, and the skin beneath becomes irritated and often ulcerated. In addition to these drawbacks, the foot of an infant is so small and yielding that it is very difficult to get a proper purchase upon it. If plaster of Paris be employed, it should be renewed at least once a week, and great care must be taken that the foot is held in the over-corrected position whilst the plaster is setting. This is difficult to do when the foot is held in position by the hands, because the bony points that have to be grasped in order to keep the foot in good position, are just those on which it is necessary that the plaster should get a good grip, and when the hand is removed, these parts are unsupported, and must be covered subsequently.

In order to avoid this difficulty the best plan, in our opinion, is to put the foot up first upon a splint (preferably Sayre's apparatus), and then to encase the whole arrangement in plaster of Paris. The foot and leg, as high as the knee are dusted with boric powder, and a woollen stocking is drawn over them. A piece of wood of suitable thickness, which may be cut from a cigar-box for a young child, is shaped to the sole of the foot, but made to extend about three inches beyond the toes (see Fig. 115). To this a long piece of strapping is attached in a manner similar to that described for talipes equinus; viz., the strapping begins on the upper surface of the splint in front, runs backwards round its posterior edge, then forwards along its under surface and around the anterior border. From this point the strapping must be long enough to reach rather more than half-way up the thigh. The strapping overcomes the equinus deformity, but a second piece should be added to the splint so as to produce eversion of the foot. This is attached to its outer border, immediately opposite the instep, carried transversely over the upper surface of the splint, around the inner border, then across the under surface to the outer border, and thence up to the middle of the thigh. The splint, padded with boric lint, is then applied to the sole, and a broad piece of

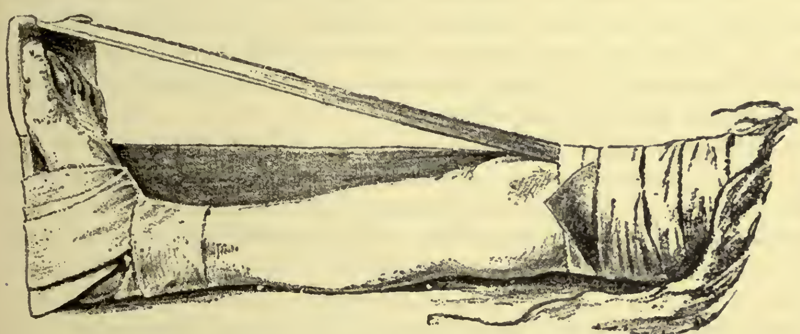


FIG. 115.—SAYRE'S APPARATUS FOR EQUINO-VARUS. This is identical with that shown in Fig. 104, except that here there is the addition of the long outside strip of strapping designed to produce a certain amount of eversion of the foot.

strapping is carried sandal-wise around its posterior end and over the instep to prevent it slipping backwards, whilst the rest of the foot is fixed on the splint with a bandage. The foot can be flexed and everted by traction upon the free ends of the two pieces of strapping, which are pulled taut on the front and outer sides of the thigh respectively, and a bandage is applied around the limb outside them. The redundant ends of the strapping are turned down over the upper edge of the bandage, and covered in by a few turns carried from above downwards, Thus the strapping and the bandage are firmly fixed to the thigh, and the foot is retained in the corrected position. A plaster of Paris bandage is then applied to the foot and leg, and the strapping may be cut through above and below the casing when this has properly set; the foot is thus kept in position whilst the plaster of Paris is applied, without the necessity of holding it by the hand. Each time the plaster casing is renewed the leg should be rubbed and the foot manipulated (see p. 347).

When the child is old enough to walk, it is better to substitute some form of apparatus for the plaster of Paris, and for poor patients the most suitable arrangement probably is Sayre's apparatus (*vide supra*) without the plaster of Paris. When walking on the flat piece of wood the child tends to evert the foot more and more, whilst the extra length of the splint corrects the equinus fully. The chief objection to the apparatus is that it requires renewal every week, and, therefore, after a few weeks it is better to fit the child with some light form of apparatus (see p. 353) which allows him to walk freely. This is all the more essential as there is often some inward rotation of the leg remaining after the talipes is cured and this may necessitate the use of lateral leg-irons fastened above to a pelvic band and so arranged as to prevent any inward rotation. An apparatus of this kind may have to be worn for several years.

In the second group of cases there are tight structures such as tendons, fascia, or ligaments, which oppose the re-position of the foot, and these must be divided in the first place. The tendons chiefly concerned are the tendo Achillis and those of the tibiales, whilst the plantar fascia and the ligaments around the astragalo-scaphoid joint, and in some cases part or almost the whole of the internal lateral ligament of the ankle joint may require division.

Although all these structures may have to be divided before the foot can be got into position, it is advisable to carry out the rectification in two stages; in the first, the varus deformity is rectified whilst the equinus is left uncorrected; division of the tendo Achillis may be undertaken when the cure of the varus has been effected. This is a matter of importance, because the tendo Achillis is of great value as forming a *point d'appui*, which fixes the posterior half of the foot and permits the proper unfolding of the anterior part. If the tendo Achillis be divided at the same time as the other structures, there will be great difficulty in unfolding the anterior part of the foot owing to the want of such a fixed point.

Tenotomy.—The first stage in the treatment consists in dividing all the various tight structures, with the exception of the tendo Achillis. In the first place, the tibial tendons which interfere with reposition of the foot must be divided, and in bad cases the tendon of the flexor longus digitorum will also require division.

Division of the Tibialis anticus Tendon.—The tibialis anticus tendon is usually divided just below the point where it crosses the ankle joint and just above its insertion into the internal cuneiform bone (see Fig. 103); at this point there is no risk of dividing any other structure. The tendon can be defined by abducting and everting the foot and thus making it tense. A tenotomy knife is inserted on one side, close to the tendon, which should be relaxed so as to allow the knife to be insinuated between it and the skin. The cutting edge of the tenotome is then turned towards the tendon, which is again put upon the stretch and divided.

Division of the Tibialis posticus Tendon.—The tibialis posticus tendon is best divided through an open incision two inches above the internal malleolus, and immediately behind it (see Fig. 103). Instead of cutting directly down on to the tendon, it is well to turn aside a flap so as to avoid any risk of adhesion of the tendon to the cicatrix in the skin. An incision, with its convexity forwards, is therefore made along the internal border of the tibia, and the flap, containing skin and fascia, is turned back until the edge of the tibia is exposed ; just behind this will be found the tendons of the tibialis posticus and the flexor longus digitorum. The former tendon lies next the bone, and a blunt-pointed tenotomy knife can be insinuated flatwise between it and that of the flexor longus digitorum. The edge of the knife is then turned towards the bone and the tendon of the tibialis divided. Should it be found that there is still some obstacle to abducting the foot, the tendon of the flexor longus digitorum may also be cut ; this, however, should be done on a different level to that on which the division of the tibialis posticus has been effected. The wound is stitched up without a drainage tube.

Division of the Plantar Fascia.—The plantar fascia if contracted must next be divided. This is necessary in many cases, and should be done near the centre of the sole. A tenotomy knife is introduced from the inner side of the foot, and carried across between the skin and the fascia ; it is important to remember that the skin is very close to the fascia, and that all resisting bands must be divided. As soon as one band is cut across, extension made upon the sole causes others to become tense, and these must also be divided, either from the same puncture or from another more conveniently situated. It is important that the division of the plantar fascia should be thorough (see Fig. 103).

In most cases also, it is important to divide the ligaments which oppose reduction. It is true that in comparatively mild cases the tight ligamentous structures may be torn across at this stage by forcibly wrenching the foot into position, either with the hand alone, or with a Thomas's wrench, but in the majority it is much better to divide the ligaments systematically in the manner recommended by Parker. The anterior part of the internal lateral ligament of the ankle joint in particular, if not divided, usually escapes tearing when the foot is wrenched, and may interfere considerably with reposition of the os calcis. Parker also lays great stress on what he terms the 'astragalo-scaphoid capsule,' which is made up, above and internally, of the superior astragalo-scaphoid ligament reinforced by fibres from the anterior ligament of the ankle joint and the anterior portion of the internal lateral ligament, and, below, of fibres from the inferior calcaneo-scaphoid ligament.

Syndesmotomy.—Under this name, Parker has described an operation by which both tendons and ligaments may be divided through one incision. He makes a puncture a little below and in front of the tip of the internal malleolus, noting at the same time the position of the tibial arteries, and the direction of the tibial tendons as they curve towards the internal cuneiform bone. As the tenotomy knife is entered, the parts are fully relaxed, and it is pushed inwards over the dorsum just above the posterior tibial artery, and in front of the tendons, to a point just above the anterior tibial vessel. Parker employs at first a sharp-pointed tenotome to make the track along which he then introduces a curved one until its tip can be felt in front of the tendon of the tibialis anticus. The cutting edge is then turned downwards, the parts fully put on the stretch, and the tibialis anticus tendon is divided; as the knife cuts down on the subjacent bones and cartilage, the ligaments yield, while, on withdrawing the knife, the tendon of the tibialis posticus is divided. The essential point in this operation is the division of the ligaments, which must be very thorough. Should the tibialis posticus not be divided on withdrawing the knife, it can be done afterwards through a separate incision (see p. 350).

Wrenching.—After these structures have been divided, the foot should be forcibly wrenched into position, and the deformity over-corrected; that is to say, the foot should be brought into a position of full abduction and eversion. If this can be effected by the hand, it is best, because the surgeon is then enabled to judge how much force he is employing, and at the same time there is not that bruising of the anterior part of the foot, which is a necessary accompaniment of the use of wrenches. Lorenz has introduced a hard wedge-shaped support which is useful as a fulcrum over which to unfold the foot and very considerable force can be exercised in this way provided that the foot be large enough to be grasped easily in the hands. When the foot is very small, however, it is difficult to get a proper hold of it, and then, it may be necessary to employ some instrument, the best being Thomas's wrench (see Fig. 116). Thomas's wrench is composed of two parallel metal bars covered with thick india-rubber, which can be approximated or separated by means of a screw in the handle. One bar is placed transversely beneath the sole of the foot, just behind the ball of the great toe, whilst the other lies parallel to it over the dorsum. The bars are then approximated until the foot is well grasped, and it is then possible to manipulate the foot with ease.

After-treatment.—When all the resisting structures, with the exception of the tendo Achillis, have been divided, a collodion dressing is applied over the tenotomy puncture, and the foot fixed temporarily on a splint. For the first three days the best arrangement is an internal splint applied to the foot and leg. When the equinus is extreme, the foot lies almost in the same straight line with the leg after correction of the varus deformity, and therefore the adduction of the foot and the inward bend at the transverse tarsal joint can be remedied by a straight internal splint applied from the knee to the toes. When the wounds have healed, it is well to put up the foot temporarily in a Sayre's apparatus, around which plaster of Paris is applied as already described (see p. 348). The subsequent treatment will depend to a large extent upon the patient's surroundings. In hospital patients who cannot afford an elaborate apparatus and who are unable to give proper attention to the care of the foot, it is best to continue with the plaster of Paris bandages, which should be renewed about once a week, for six months. Every time the bandagės are renewed the leg should be well rubbed and the galvanic current applied to the muscles.

At the end of about six weeks, or in some cases even earlier, it will generally be possible to carry out the second stage of the treatment, namely the correction of the talipes equinus. Before doing this, however, the foot must be examined to see whether any fresh contraction of the ligaments or the plantar fascia has occurred. Should contraction have recurred, the tenotomy and wrenching must be repeated before the tendo Achillis is divided. The best indication as to the proper time for the correction of the talipes equinus is that the foot should retain its corrected

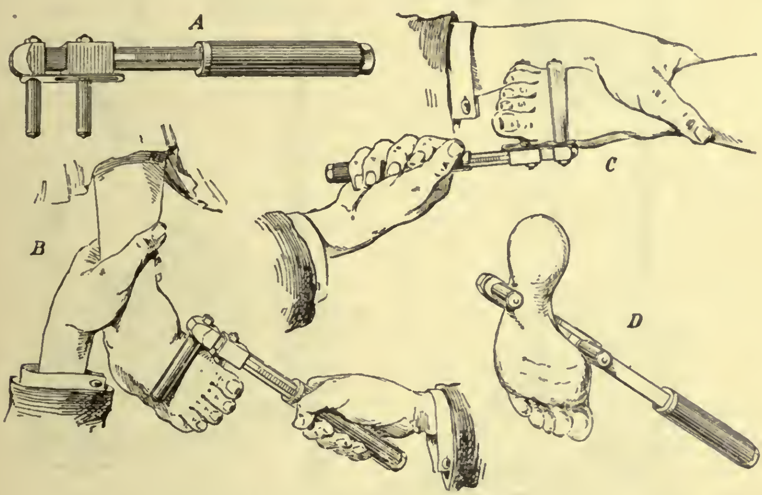


FIG. 116.—THOMAS'S WRENCH.—*A* shows the wrench, *B*, *C*, and D the methods of using it in a case of talipes equino-varus. (*Robert Jones*.)

position when the apparatus is taken off, or, at any rate, it should be possible to make it resume it at once by gentle pressure. When this stage has been reached, the tendo Achillis is divided and the equinus treated on the lines already laid down (see p. 322). About three weeks later the patient may be allowed to walk about wearing a suitable apparatus; for poor people the most convenient is Sayre's (see Fig. 104) which should be renewed every week.

If the patient can afford a suitable apparatus, it is best to employ a suitable shoe or splint about three weeks after the tenotomy; with the use of this should be combined massage and the application of electricity. In infants the light metal splint already described (see p. 316) is the best. This splint should be applied with the foot in the faulty position, and the varus deformity subsequently over-corrected; it should be taken off night and morning for massage and galvanisation of the muscles.

When the child learns to walk, or when treatment is not begun until the child is able to walk, a Scarpa's shoe may be applied and should be worn continuously for many months and sometimes for years. Although the deformity may seem to be corrected perfectly, it takes a considerable time for the shape of the bones to be influenced materially, and the deformity will inevitably be reproduced if the apparatus be left off too soon, and often in a more severe form than the original one.

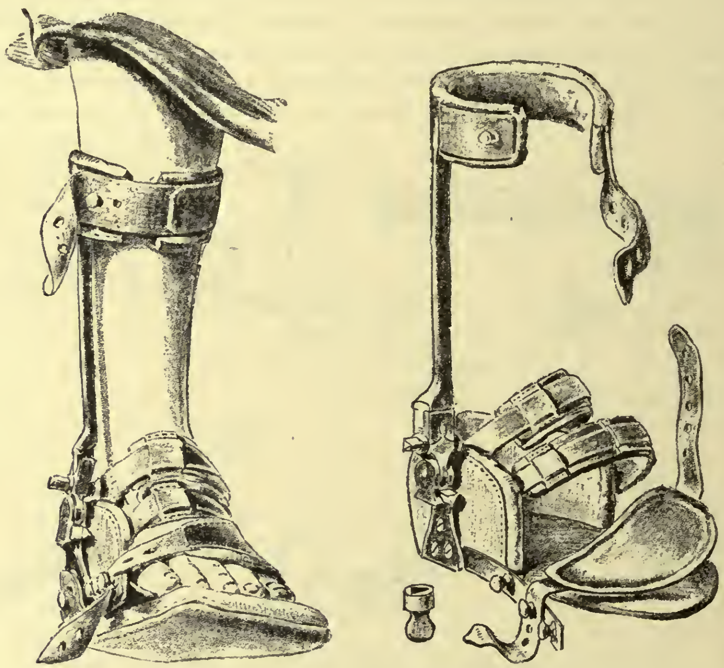


FIG. 117.—SCARPA'S SHOE. On the right-hand side is seen the apparatus before use. The two ratchets (turned by the key shown below the figure), the lower one for flexing and extending the ankle, and the upper for inverting or everting the foot, are seen near the junction of the outside leg-iron with the foot-piece. The broad sling used to pull outwards the front part of the foot is also seen in front attached to a button on the end of the stout spring attached to the outer side of the sole and exerting a forcible outward pull.

In the left-hand figure the apparatus is applied to a case of equino-varus. The foot is firmly everted, the toes raised, the heel depressed, and the front half of the foot pulled outwards.

In *Scarpa's shoe* (see Fig. 117) there is a leg-piece applied to the calf, on the outer side of which is attached an iron bar connected with a foot-piece. Opposite the ankle there are two hinges, one corresponding to the ankle joint proper, from which flexion and extension of the foot-piece is made, whilst the other raises or depresses the side of the foot so as to bring it into a position of eversion or inversion. A strong spring bent considerably outwards is fixed to the outer side of the front of the foot-piece and from this a band is carried around the anterior part of the foot which can thus be brought into a position of abduction, by the outward pull of the spring. In some forms of the apparatus this movement is reinforced by a joint in the foot-piece beneath the instep, which is made to carry the front half outwards, by means of a screw; this effects more powerful abduction of the front of the foot.

When applying a Scarpa's shoe, the apparatus is first screwed into a position corresponding with the deformity, and the heel is carefully fixed down to the foot-piece by the appropriate straps. The apparatus is then fastened to the leg, and the various racks are turned with keys, and the deformity is reduced as far as possible without giving pain. The reduction should not be carried so far as to cause pain, and there should be no undue pressure upon the straps which pass across the instep and fasten the heel to the splint, as otherwise sores may form beneath them. Much more will be done by gentleness and gradual reduction of the deformity than by any violent attempt to over-correct it at once; the correction should be increased gradually until the deformity is over-corrected (see Fig 117).

The apparatus is best suited for children who can walk; in a very young child the foot is too small for the shoe to get proper purchase, and therefore the lighter metal splint is preferable. The shoe should be worn night and day, and should only be taken off for toilet purposes and for massage. The child may walk while wearing the apparatus, and its use should be continued for a year or two, when a lighter apparatus may be substituted for it, which will have to be worn for two or three years longer. As soon as the foot will retain its position when the child stands or walks, the splint may be dispensed with, but even then it is well to see that the boots are made to a cast of the foot in its corrected position, and in some cases a suitable spring or an artificial sole is requisite to raise the outer border of the foot. Even after the lapse of this length of time it is well to put on the apparatus at night for another year or two in order to prevent the foot assuming the faulty position during sleep.

The most severe Cases of Deformity—The greatest difficulty arises in the treatment of the third group of cases in which the most important obstacle to reduction is permanent alteration in the bones. These cases may be divided into those in which the patient is still young and the bones are soft and capable of being moulded, although the deformity in the osseous structures of the foot may be considerable, and those in which the condition has remained untreated into adult life, and in which therefore the bones are fully ossified and unyielding. In young subjects it is sometimes possible, even when there is marked deformity, to alter the shape of even considerably deformed bones and to bring the foot gradually to its proper position by keeping up continuous pressure in the desired direction; this treatment is carried out in combination with free division of the resisting soft structures. In the more advanced cases, however, it is necessary to employ operative interference to remedy the deformity of the bones.

The treatment of the first group of cases consists either in dividing all the resisting structures subcutaneously, and bringing the foot forcibly into position by wrenches, after which an apparatus, designed to keep up constant pressure on the bones, is applied, so as to mould them to their natural shape; or in performing an open operation by which all the soft structures causing the faulty position of the foot are divided, and subsequently applying pressure in such a direction as to produce the required alteration in the shape of the bones. This is commonly known as 'Phelps' operation.'

The forcible restoration of the foot with wrenches after all the resisting soft structures have been divided subcutaneously is done in the manner already described (see p. 352). Any tight tendons, the astragalo-scaphoid capsule, the plantar fascia and the internal lateral ligament of the ankle joint, are divided with a tenotome and this is followed by wrenching of the foot, so as to tear any ligamentous structures that may have escaped division. The later treatment consists in dividing the tendo Achillis and employing apparatus to keep up constant pressure on the foot in the right direction, and thus gradually to alter the axes of the deformed bones. Nothing further need be said here concerning this method which is only an extension of that already described for the second group of cases.

In carrying it out, subcutaneous division of the tight structures must often be repeated after an interval of a few weeks, and the wrenching also requires more than one repetition. If success be not attained after a fair trial of this method for six months or a year, the surgeon must employ Phelps's operation or some modification of it.

Phelps's operation is performed as follows. The foot is placed on its outer side upon a firm sandbag, and an incision is commenced about half an inch in front of the tip of the internal malleolus, and extended downwards and slightly forwards, to the sole. This incision should not go farther down than the middle point of the sole, as otherwise trouble may ensue afterwards from pressure upon the scar in walking; it should commence above, in close proximity to the tendon of the tibialis anticus, and should divide all the structures down to the bone, parallel to, and slightly in front of, the marked transverse crease in the foot which corresponds roughly to the mid-tarsal articulation. The tendons of the tibialis anticus and posticus muscles, the plantar fascia, the abductor hallucis, the flexor brevis and part of the flexor longus digitorum, together with the internal plantar vessels and nerve, are divided in this incision. A portion of the internal lateral ligament of the ankle joint, and the ligaments about the mid-tarsal joint, are also cut, and thus the head of the astragalus is exposed. The foot is next forcibly wrenched into a position of abduction, and after this a deep triangular gap is left in the position of the incision, which may either be allowed to heal by granulation, which is a slow process, or may be covered by skin-grafts (see p. 52).

The foot is secured to a splint in the over-corrected position. Should the tendo Achillis require division, as it generally does, this is better done after an interval of six or eight weeks, for reasons already mentioned (see p. 350). When the wound has healed, the foot may be put up in plaster of Paris, and the after-treatment requires careful attention. In these bad cases there is a strong tendency for the deformity to recur, and this is greatly aided by the contraction of the large scar left on the inner side of the foot ; care must be taken therefore to counteract this tendency. The safest way to prevent recurrence is to over-correct the deformity so fully, by free incision of the astragalo-scaphoid articulation, that the foot is actually in a condition of slight valgus. Locomotion then becomes a valuable aid in preventing any recurrence of the varus. The treatment of these cases after the wound has healed is similar to that for those in which a less severe operation has been done.

In order to mitigate the severity of this operation, it has been done subcutaneously by introducing the knife between the skin and the deeper parts, and then cutting everything right down to the bone. The objection to this is that the skin itself is always markedly shortened, and will not stretch ; sloughing therefore is likely to occur from the pressure of the extravasated blood beneath the skin, which is rendered unduly tense both by it and by the pressure brought to bear when the foot is forcibly straightened.

Phelps's operation has been very successful in many cases, although it is a somewhat drastic one. The operation is more suitable for young children in whom the bones are still soft, and in whom the soft parts have contracted to such an extent that the deformity cannot be remedied by mere subcutaneous division. It is not likely to be so successful in adults, or in those in whom the bone changes are extensive and permanent. It has little chance of success in any case unless the incision and wrenching are so free that the foot afterwards is actually in a position of valgus rather than varus. It is neglect of this precaution that has led to so many unsuccessful results.

The operation required for the most severe cases, such, for instance, as those where the patient has been allowed to grow up with the deformity uncorrected, will necessarily be more radical, and must involve *resection of some portion of the tarsus.* Whether or not operative interference should be undertaken will depend very much on the functional condition of the foot ; some of these patients become so accustomed to use the limb with the foot in the deformed position that they can walk well, and hence it is inadvisable to suggest operation to them, considering the severity of the operation, and the more or less imperfect result which may follow it. In other instances, however, there is so much pain and difficulty in walking from the formation of bursæ on the outer side and dorsum of the foot, which are constantly liable to repeated attacks of inflammation, that the patient urgently demands relief by operation, which is then fully justified.

Amputation.—In those cases in which the exaggerated deformity is the result of infantile paralysis, and in which there is almost complete uselessness of the foot, the question of amputation will arise. The answer mainly depends upon the vitality of the parts. In the paralytic forms the tissues are often imperfectly nourished, ulcers are liable to form from the most trivial causes, chilblains are common, and consequently the result of extensive operations upon the skeletal structures of the foot is not satisfactory. Under these circumstances therefore it is much better to amputate, and to fit the patient with an artificial limb, as he will then have a useful limb and be free from trophic troubles, which would not be the case after any partial operation which involves retention of the foot. In the congenital cases on the other hand, in which the nutrition of the foot is good, the question of amputation will only arise very rarely; it is only called for when repeated attacks of inflammation and suppuration in the various bursæ, possibly extending into the joints, have rendered the chance of remedying the condition by any form of tarsectomy very remote indeed. In such cases, Syme's amputation will leave the patient in a much better condition than before operation, or than could be obtained by any form of tarsectomy.

The osteo-plastic operations practised for the cure of club-foot are numerous, but for practical purposes they may be divided into two groups. In the first are those in which one or more of the tarsal bones are excised, and in the second are the operations involving the removal of wedge-shaped portions of the tarsus without any regad to the articulations of the portion removed. The operations included in the first group are numerous. Various tarsal bones, more particularly the astragalus and the cuboid, have been removed, but the results do not appear to be particularly good; removal of the astragalus, although of some value as a cure for the equinus, does not seem to influence the varus part of the deformity to any extent.

The removal of wedge-shaped portions of the tarsus without regard to the articulation of the portion removed, on the other hand, is a valuable method. The operation, which is generally spoken of as '*cuneiform tarsectomy*,' consists in removing a wedge-shaped portion of the tarsus at the transverse tarsal joint by means of a saw or chisel, the portion thus excised having its base directed outwards and slightly upwards, whilst its apex is at the inner border of the sole. The amount of bone taken away will vary with the degree of deformity present, the object being to remove sufficient to permit the outer border of the foot to be shortened to the degree requisite to bring the concave inner border straight. The parts included in this excision generally comprise portions of the os calcis, astragalus, cuboid, and scaphoid.

The operation is performed as follows. The limb is steadied upon a sandbag, and the surgeon divides all the shortened tendons, fascia and ligaments that can be reached on the inner side of the foot with a tenotomy knife. This is similar to Parker's syndesmotomy (see p. 351). It is important to do this before proceeding to divide bone, as otherwise an unnecessarily large amount of the tarsus will have to be removed in order to get the foot into position. One of the most important features in this preliminary procedure is the free division of the front part of the internal lateral ligament of the ankle joint, which will allow the os calcis to be pressed outwards towards its normal position, for in these bad cases the patient generally walks upon the outer side of the os calcis as well as upon the outer aspect of the dorsum of the foot. It is also advantageous to amplify the freedom of movement obtained after tenotomy by the use of Thomas's wrench (see p. 352).

FIG. 118.—CUNEIFORM TARSECTOMY FOR TALIPES EQUINO-VARUS. The black line indicates the incision. The darker portion indicates the amount of bone that must be removed.

After all the tight structures on the inner side of the foot have been divided or stretched to their utmost extent, the surgeon makes an incision along the outer border of the foot, commencing at the base of the fifth metatarsal and terminating just in front of and about an inch below the tip of the external malleolus. This incision is carried directly down to the bone, and the soft parts are raised in one mass from both dorsal and plantar surfaces of the tarsus with a periosteum detacher. The operation is greatly facilitated by making a second incision along the inner border of the foot, commencing just below and in front of the tip of the internal malleolus and terminating a finger's breadth behind the base of the first metatarsal. This enables the soft structures to be raised from the bones on the inner side and thus the tarsus can be denuded of all the soft structures, above and below, opposite the two incisions. It will be necessary to divide a portion of the extensor brevis digitorum muscle at its origin, and the insertion of the tibialis posticus tendon into the scaphoid will probably be cut through. The soft parts are retracted and protected from injury by introducing beneath them flexible copper spatulæ of suitable breadth, by which they can be pulled away from the bone.

The next stage is the removal of a wedge-shaped portion of the tarsus. The amount of bone to be removed will depend upon the degree of the deformity, only sufficient being taken away to enable the foot to come straight. The section through the bone is best effected by a broad chisel (by means of which the surgeon is enabled to vary the amount removed at different parts), but it is well to mark out the intended dimensions of the wedge with a narrow saw as a preliminary measure. The base of the wedge looks towards the upper and outer surfaces of the tarsus, while its apex is at the inner border of the sole. After the section has been made, the bleeding is arrested and the foot brought into position ; if the section has been made as directed above, the front part of the foot will be raised and brought into a position of slight abduction. If the position be not satisfactory, more bone may be sawn off ; if it be, the incisions are stitched up without a drainage tube. It frequently happens that the skin over the instep is made very tight when the foot is brought into the corrected position. This is due to shrinkage resulting from the long continuance of the limb in its faulty position, and if both the incisions were stitched up longitudinally a deep transverse groove would form between them over the dorsum of the foot, and the tension would be so great as to cause sloughing. We are, therefore, accustomed to stitch up the wound on the inner side in the ordinary way first, and then, to suture the external one in any manner that will give rise to the least tension of the skin over the instep after having brought the foot straight. As a rule this incision takes a somewhat ⊥-shape ; that is to say, a certain portion of it at either end is stitched up longitudinally, but the central portion of the upper edge of the wound is folded upon itself and sutured (see Fig. 119).

Fig. 119.—Method of Suturing the Wound after Cuneiform Tarsectomy. The upper lip of the wound is folded upon itself about its centre and the adjacent edges sutured together.

After the wound has been sutured and the dressings have been applied, the foot is placed upon a back splint furnished with a foot-piece at right angles, and care must be taken to see that the os calcis as well as the anterior part of the foot is fully everted. It is well to leave the division of the tendo Achillis until union has occurred between the bony surfaces. After the stitches have been removed, the foot is put up in plaster of Paris in the rectified position and is kept there for a month. The tendo Achillis and, if necessary, the posterior ligament of the ankle joint, should be then divided.

In very severe cases, characterised by extreme inversion of the os calcis and severe equinus, it may be advisable to begin by excising the astragalus (see p. 332). This enables the equinus to be remedied and the inversion of the os calcis rectified. The varus part of the deformity can be treated by a cuneiform tarsectomy undertaken some months later.

The after-treatment is similar to that recommended for talipes equinus (see p. 326), the chief trouble being the inversion of the os calcis, which is most difficult to remedy. The patient must be kept under mechanical treatment by suitable shoes for at least two or three years, for, even after an operation of this radical nature, a relapse may occur if the treatment be abandoned too soon. Should any tendency to a relapse manifest itself, it may be overcome at an early stage by wrenching the foot and again putting it up in plaster of Paris; but even up to the end of his life the patient should wear specially strong boots with the sole somewhat thickened along the outer border, and the inner side of the boot cut straight, and made of very stiff leather so as to prevent adduction of the front part of the foot.

CLUB-HAND.

This deformity is comparatively rare. The commonest variety is caused by congenital absence of the radius, and in most cases is associated with absence of the thumb. Other cases occur in which there is a congenital contraction of the muscles, usually associated with wasting, producing a condition analogous to that found in the common variety of talipes equino-varus. The hand is deflected to one side and, in congenital absence of the radius, lies in contact with the forearm, the fingers pointing towards the elbow joint.

TREATMENT.—This is unsatisfactory, but the hand is almost useless if left alone. In very young children the muscles and tendons are so delicate and friable that any operation for lengthening them is out of the question. Further, the skin on the radial border of the hand is so contracted that if an attempt be made to rectify the deformity by dividing the skin, an exceedingly large wound is left, the cicatrisation of which leads to troublesome swelling of the hand. Much can be done by manipulation, however, and this should be commenced immediately the child is born. The hand is gently stretched until it is nearly in a line with the forearm; a small tubular poroplastic felt splint is then moulded around the wrist so as to maintain the correction. As the child gets older, the shape of the splint can be modified, and in this way considerable improvement may be obtained. Operative interference should not be attempted until the child is at least five years old. The contraction of the skin is best remedied by the use of the Y-shaped plastic operation described on p. 295, and many of the tendons require lengthening (see Vol. II.). After the tendons have been divided, but before they have been sutured, the soft parts should be separated from the lower end of the ulna, and the bone made to protrude through the wound. The bone is divided lengthwise with a fine saw for about two inches, the plane of the saw cut being at right angles to that of the palm. A periosteum detacher is then inserted into the saw-cut and the two portions of bone forced apart; this will cause one of them to undergo a greenstick fracture. At the carpal end of the cut the periosteum at the end of each portion of bone is now sutured by a stout catgut thread to the carpus; one to the radial and one to the ulnar side. The divided and lengthened tendons are now sutured together and the wound closed as far as possible. If the wound cannot be completely closed it should be allowed to granulate and then skin-grafted. When healing has taken place, the hand should be maintained in the same line with the forearm by encasing them in a tubular sheet of poroplastic felt extending from the middle of the forearm to the base of the fingers. The absence of the thumb makes the application of the splint quite simple. For the cases in which both bones are present, the most suitable treatment is by manipulation and massage combined with the use of the poroplastic splint as described above.

The results of this treatment are, however, far from ideal as there is always a considerable amount of muscular weakness.

CHAPTER XVII.

CURVED TIBIA AND FIBULA.

CURVATURE of the bones of the leg is one of the commonest results of rickets. A certain amount of curvature of these bones may also occur in syphilis, osteitis deformans, osteo-malacia, and some other diseases. In the cases due to rickets the degree and situation of the curve vary considerably. The most usual condition is a uniform curvature of the entire shaft of the bone with the convexity outwards and somewhat forwards, whilst the shaft becomes flattened from side to side, and there is a tendency to an increased production of bone in the concavity which acts as a support. In other cases the bend, which is somewhat more acute, occurs either just above the lower epiphysis or, more rarely, a little below the upper. This may be met with either alone or in combination with the uniform outward curvature. In rare cases the tibia may be convex inwards instead of outwards. The conditions met with most frequently, however, are an outward bowing of the tibia or an acute anterior curve immediately above the ankle, or a combination of the two.

TREATMENT.—This should be partly general and partly local.

The general treatment should be that appropriate for rickets, since this disease is the primary cause of the deformity. The whole subject of rickets is discussed in Vol. II.; here we need only say that its treatment is partly dietetic and partly hygienic. We append the table of directions given to the mothers of rickety children at Paddington Green Children's Hospital. These rules embrace both dietetic and hygienic instruction, and, although mainly designed for the use of hospital outpatients, may, with a little modification, be applied to private practice.

FEEDING.

I. **If the Mother is perfectly healthy and has plenty of Milk,** breast milk alone should be given until the infant is 8 months old.

Suckle every 2 hours by day, and twice by night, until the child is 3 months old; then suckle every 3 hours by day and once only by night. Too frequent suckling makes the milk poor and does not satisfy the baby.

The mother's nipples should be bathed with warm water both before and after suckling. Also wash the inside of the child's mouth with a small piece of clean linen and warm water after taking the breast. This will prevent 'Thrush.'

Begin to wean at 8 months, and wean completely at 9 months.

Between the eighth and ninth months let the child have three times a day a mixture of two parts of cows' milk and one part of barley water, sweetened with one lump of sugar or one-third of a teaspoonful of malt extract to each bottle. The cows' milk should be just brought to the boil.

The barley water is made as follows: Wash one tablespoonful of pearl barley and put it in a saucepan with one pint of cold water. Let it come to the boil, and then simmer beside the fire for half-an-hour. Strain and use as required. Should be prepared twice daily.

II. **If the Mother has only a little Milk,** the child should still have it: give also one part cows' milk and two parts barley water, made and sweetened as above.

There is no harm in mixing the milks. It is better to get ordinary dairy milk than milk from one cow.

Should diarrhœa or vomiting come on, give equal parts of milk, lime water, and barley water.

III. **If for any reason the Breast cannot be given,** feed as follows:

Up to 3 months.—One part of cows' milk and two parts of barley water—prepared and sweetened as above—every 2 hours by day and twice by night. Give one-sixth of a pint of the mixture at each feed, and add a little more milk each week until—

Between 3 and 6 months.—Equal parts of cows' milk and thin barley water may be given, 1½ to 2 pints a day. One-third of a teaspoonful of fresh butter, or a teaspoonful of cream may be given twice daily in the milk. Feed every 3 hours by day, and once during the night.

Between 6 and 9 months.—Two parts of cows' milk to one part of barley water. Then add gradually more milk and less barley water until at 9 months the child is taking plain milk.

On no account give any infants' food, condensed milk, bread, biscuits, or tops and bottoms until the child is 9 months old—except by doctor's orders.

If the cows' milk does not seem to agree, consult a doctor—not the chemist.

Never give babies at any age sweets, pastry, fruits, cheese, salt meat, salt or fried fish, tea, wine, beer, or spirits.

Between 9 and 12 months.—Besides 1 pint or 1½ pints of cows' milk, the child may be given, not oftener than twice in the day, any plain milk pudding, or porridge made with milk, or bread and milk made as follows: Put a slice of stale bread without crust to soak in a basin of cold water for 2 hours; then pour off the water, beat up the bread, and pour over it a quarter of a pint of boiling milk; sweeten with loaf sugar. This should be freshly made for each meal.

Between 12 and 18 months.—Add to the above, potato and gravy, or half an egg once in a day. After 15 months, feed every 4 hours by day and not at all during the night.

After 18 months.—Finely minced or shredded mutton and fresh fish may be added to the above, but cows' milk should still be the principal food.

Feed only at meal times, never between meals, 'Just to keep the baby quiet.' Babies often cry not because they are hungry, but because they are thirsty. A little pure water or barley water, flavoured with orange juice, will satisfy them.

The bottle should have a nipple, but no tube. Scald it out both before and after use, and cleanse with a brush.

Prepare at a time only enough milk for one meal. Never give what is left over in the bottle for the next meal. Taste the milk before feeding, and be sure it is not sour or smoked.

GENERAL DIRECTIONS.

I.—*Sleeping.*—The child should sleep in a cot or basket alone. Many babies are overlaid every year from sleeping with their parents.

If babies kick off the bedclothes, put them in long flannel nightgowns, fastened below the feet and at the wrists and throat. They must not lie between window and door, or fireplace and door. Keep the window open all night in hot weather. Keep a small fire burning all night in cold weather.

II.—*Clothing.*—Should be loose round the chest and close round the belly. Do not let them go about with nothing on below the armpits but petticoats. A flannel binder round the belly and warm drawers should always be worn.

III.—*Washing.*—Wash them all over with soap and warm water night and morning. Dirty children are always delicate. They will not take cold if carefully dried, especially about the head and ears, after the bath. It is a good plan to put them to bed between the blankets for half-an-hour after the morning bath.

IV.—*Fresh Air and Sunlight* are nearly as important as food to children. Take them out every day in fine weather.

A perusal of these rules will show that the dietetic treatment consists largely in the avoidance of too much farinaceous food, and—a point of particular importance—the withholding of it at an early period of life. The hygienic treatment is directed essentially to obtaining an unlimited supply of pure fresh air and sunshine. If possible, the children should be sent away to the country, and of course any other measures for improving the general health that may be found appropriate to any individual case should be adopted. Amongst drugs, cod liver oil is the most generally useful, and in these cases it may be combined with phosphorus, $\frac{1}{100}$th of a grain of the drug being added to each dose of the oil.

Vinum ferri (dose ʒss—ʒj), or syrup of the hypophosphites (dose ʒss—ʒj) may also be given. The state of the digestive organs will require particular attention, and special care has to be taken to prevent the occurrence of constipation.

Local Treatment.—It is important to bear in mind that, in the early stages of the disease, there is a marked tendency to the spontaneous cure of the curvature, and, to facilitate this, the first essential is to prevent the patient walking, and thus to *take the weight of the body off the feet*, and so to avoid increasing the curve mechanically. Appropriate general treatment must not be neglected. In many of the slighter cases, when the patient is properly dieted, put under suitable hygienic conditions, and prevented from bearing weight upon the limb or from lying with the limb on its outer side (which would increase the curve), the bones undergo solidification, and the curve not only ceases to extend, but disappears entirely.

It is advantageous to employ *massage* and *electricity*. At the same time the limb may be *douched* and attempts made to reduce the curvature by steady *manipulation* ; a great deal can be done by the nurse in this direction. The limb should be grasped at the extremities of the curve, the thumbs applied opposite the point of greatest convexity, and the bone may be straightened by steady and gradual pressure which does not cause the child pain.

In the more advanced cases, when there is distinct bending of bones which are still soft (as will be the case when the rickety condition is active), the use of *splints* and internal remedies will often ensure a satisfactory result, if the child be prevented from walking. We prefer a straight internal splint of wood, slightly wider than the antero-posterior diameter of the leg, extending from the internal condyle of the femur to six inches beyond the sole. It requires careful padding opposite the tuberosity of the tibia and the inner malleolus, so as to avoid the possibility of ulceration from pressure. The splint is made to extend well beyond the foot, and not just an inch or two as is usually recommended, in order to prevent the patient putting the toes to the ground ; when it does not project far enough, it is possible for the child to walk about on the points of the toes. The splint is firmly fixed above and below with straps and buckles, and a broad piece of elastic webbing may be applied opposite the point of greatest convexity, so as to draw the limb gently inwards against the splint (see Fig. 120). When the curve is very marked, so that there is a considerable tendency for the splint to slip round, it is a good plan to have a light iron bar screwed to the lower end of the splint and fastened to the heel of the boot so as to prevent rotation.

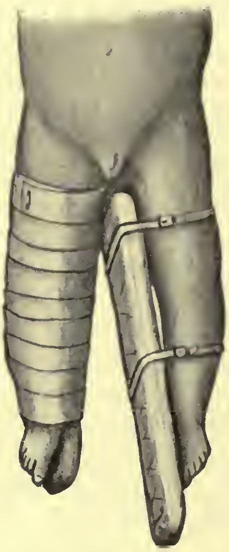


Fig. 120.—Simple Apparatus for Bow-leg. The splint is bandaged in position on the right side ; on the left, it is simply fastened with straps and buckles. The two splints are of unequal length so as to prevent the child from walking.

Although a great deal has been written about the influence of splints of this kind in straightening these curvatures, their real function is to prevent the deformity from becoming worse, and thus allow nature to obliterate it as growth progresses. This point is of the highest importance in practice, because, should the surgeon be under the impression that he is able to obliterate the curve by splints, he is apt to apply so much force as to produce ulceration at the points of greatest pressure, namely, over the convexity of the curve or opposite the knee and ankle. It may be safely said that, unless the bones are so soft that they can be straightened by the hand, the application of splints can produce little alteration. Massage and electricity (*vide supra*) should also be employed.

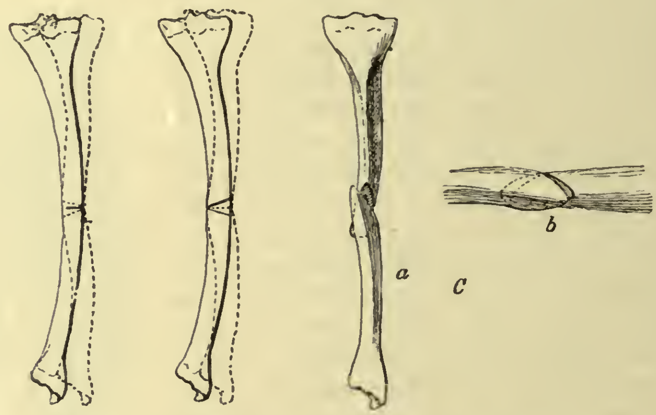
The mechanical treatment of the *acute anterior curvature* immediately above the ankle is unsatisfactory, and operation will be called for in most cases, after the acute stage of the rickets has passed off. In the meantime the child should be kept off his feet by means of suitable splints.

In cases of marked curvature when the bones have undergone solidification, as is usual in children over the age of four or five, *early operation* is advisable. The chance of straightening the limb by splints is extremely slight, and it is a waste of time and money to persevere with them. The exact nature of the operation will be determined by the precise form and extent of the curve; the seat of the operation will also to some extent be determined by the same factors. When there is a general concavity of the tibia inwards, division of the bones should be practised about the centre of the curve. When the curve is limited to either the upper or lower part of the bone, division should be practised opposite the point of greatest curvature. In the antero-posterior curvatures at the lower end, the bone should be divided at the acute angle formed by the curve.

Fig. 121.—Tracing from a case of Curvature of the lower end of the Tibia treated by Simple Splinting. The age of the child is shown upon the lines, which indicate the long axis of the foot.

Several points require consideration in connection with the operation. The surgeon may either simply divide the bone, *i.e.* he may perform a linear osteotomy, or he may remove a wedge-shaped portion from it. It is also important to consider whether the fibula requires division or not; sometimes this bone is so soft that it can be bent without being broken, and at most a greenstick fracture may be produced by bringing the limb into position. When either of these procedures can be carried out, it is of considerable advantage, as if division of the fibula can be avoided, there is only a single wound, and a fairly strong bone is left to act as a splint to the other. When, however, the rickety condition has passed off and the bones have undergone complete consolidation, and more particularly when the case is one of antero-posterior curvature at the lower end of the bone, it may be necessary to divide the fibula as well as the tibia. The bone can be exposed at the requisite spot by a small incision over its outer surface and divided with cutting pliers after the periosteum has been separated by a rugine. Removal of portions of the fibula is only called for when the curve is very extreme and the bones will not come straight until the ends of the fibula overlap one another ; enough must then be removed to bring the ends into contact without overlapping.

The main factor influencing the choice between linear osteotomy and



A B

FIG. 122.—VARIOUS FORMS OF OSTEOTOMY OF THE TIBIA.

A. Simple Transverse Linear Osteotomy. The thick lines show the original position of the bone and the line of bone section. The dotted ones show the position of the fragments when the bone is straightened. It will be seen that a large gap, which may lead to non-union is left when the curve is marked.

B. Cuneiform Osteotomy. It will be seen from the figure how the triangular gap is converted into a linear division when the bone is straightened.

C. Oblique Osteotomy. The first figure shows the oblique method applied to a lateral bending of the bone—in this case a curvature outwards—while the second shows it applied to an antero-posterior curve, the upper border of the figure being the crest of the tibia. The figures also show the method of rotation after the section has been made.

removal of a wedge from the tibia is the degree of curvature present. When this is not very great, *linear osteotomy* will meet the requirements of the case ; when the curvature is extreme, and especially when it is so acute as to form almost an angle, it is advisable to remove a wedge. This is particularly the case in the antero-posterior curves at the lower end of the bone, in which transverse division of the tibia will not allow the deformity to be rectified ; the only procedure which makes this feasible is the removal of a wedge with the base directed forwards. In the ordinary bow-legged deformity the base of the wedge removed should of course look outwards.

Cuneiform osteotomy of the Tibia.—The operation is performed by making an incision down to the bone along the crest of the tibia over the point of greatest curvature for a distance that will vary with the amount of bone requiring removal. The periosteum is separated on each side by a rugine, and then a wedge of bone is removed by means of a chisel; a simple method of procedure is to use a saw for marking out the portion of bone to be removed, and to complete the division with the chisel. This is preferable to using the saw throughout, as there is some danger of injuring the structures of the calf when the posterior surface of the tibia is divided.

After enough bone has been removed to allow the limb to be brought straight, the wound is stitched up and the dressings are applied. It is seldom necessary to fasten the fragments together, but, in cases of marked antero-posterior bending just above the ankle, it is sometimes of advantage to do this in order to prevent the foot from falling back. In these cases also it is sometimes well to divide the tendo Achillis, which would otherwise have a great tendency to pull the heel back.

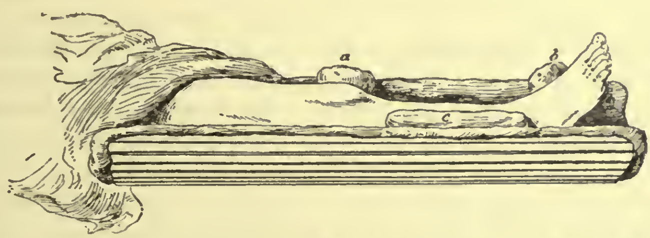


FIG. 123.—METHOD OF PUTTING UP THE LIMB AFTER OSTEOTOMY OF THE TIBIA. For the sake of clearness no dressings are shown applied to the limb. There is one fairly long pad (*c*) applied over the convexity of the curve, and two small thick ones (*a* and *b*) on the opposite side of the limb, between the spint and the inner condyle of the femur above, and the inner malleolus below.

When linear osteotomy is preferred to the cuneiform variety, it is well, if possible, to make the section of the bone as *oblique* as possible, so as to get a broader surface for union, and in Fig. 122 is illustrated a method by which this oblique section can be so adapted to different curvatures as to allow the deformity to be reduced with the least separation of the bony surfaces.

After-treatment.—The limb should be put up on a splint, and for this purpose we generally employ a trough of Gooch's splinting (see Fig. 123) for the first few days until the wound has healed and the stitches are removed. The splint is wide enough to surround rather more than half the limb, and extends from the fold of the buttock, where it is cut away obliquely from within outwards and upwards, to well below the foot. A portion should be cut out opposite the heel so that no injurious pressure shall be exerted, but in small children this need not be done, as the padding may be so arranged that the heel is pushed somewhat forward and does not press upon the splint. The limb is made to fit the splint by packing pads of suitable size and shape on each side and behind the limb, which may thus be fixed in any position that is most suitable. Any desired amount of inversion or eversion of the foot can be obtained by graduating the padding; generally speaking, a large long pad should be applied opposite the point of greatest convexity of the curve that it is required to obliterate, and smaller thicker ones between the ends of the bones and the sides of the splint. The latter is then fastened round the limb by broad bandages, and the whole is laid upon an inclined plane to which it may be secured by a bandage.

In about a week the stitches may be removed, and a collodion dressing applied. Any additional correction of the deformity may then be made, if necessary, under an anæsthetic, and the limb put up in the fully rectified position in a plaster of Paris or silicate bandage for another week or ten days; it is of course necessary that the foot should be strictly at right angles to the leg. As soon as the wound has healed, the case may be treated as one of a simple fracture in which there is no displacement of the fragments. The patient should be kept in bed with a firm sandbag on each side of the leg. Twice a day the leg is thoroughly massaged, and at the end of four weeks sufficient union will be found to have occurred to prevent any recurrence of the deformity. The child may now be allowed to sit up wearing the simple splints recommended above for the early stages of curvature, the splints being removed night and morning for massage. In this way it is possible to avoid the extreme muscular wasting which often follows osteotomy when the leg has been encased for months in a rigid plaster of Paris casing, and in addition, union of the divided bone takes place more rapidly. About six months after the operation the patient may be allowed to walk without any apparatus.

CHAPTER XVIII.

GENU VALGUM: GENU VARUM: GENU RECURVATUM.

GENU VALGUM.

BY the term genu valgum or knock-knee, is understood a deformity of the lower extremity in which the leg is deflected outwards, so as to form with the thigh an angle which is smaller than the normal. It may appear at two periods of life; either during the first five or six years of life or during adolescence.

CAUSES.—The ordinary form of the affection arises spontaneously, but a similar deformity may appear under other circumstances. For example, it may follow some injury or disease of the lower end of the femur, which destroys the outer part of the epiphyseal line, so that normal growth takes place on the inner side, but is arrested on the outer, and the leg, therefore, becomes deflected outwards. Some degree of genu valgum is fairly common in association with osteo-arthritis of the knee joint, and it is also met with in connection with Charcot's disease of the knee. It is also a not infrequent sequela of infantile paralysis, and it may result from any accident involving rupture or extreme stretching of the internal lateral ligament of the knee joint. It may sometimes arise after excision of the knee, when the patient is allowed to get about too soon, and the weak union between the bones yields and allows the production of this angular deformity; another cause of its occurrence after excision is that the bone section may have damaged the outer part of the epiphyseal line, and have left the inner part intact, so that growth occurs normally on the inner side, while it is arrested on the outer.

We shall only deal here with those forms of genu valgum which occur spontaneously in infants and young adults without the occurrence of any injury, operation, or paralysis. There has been considerable discussion as to the nature of the deformity in this variety. Recent researches, in particular the work of Mickulicz, show that there is no change in the epiphyses of the femur or the tibia either in the child or in the young adult, and that there is no increased length in the internal condyle, and no diminution in the external; the whole change apparently occurs in the diaphysis in the immediate neighbourhood of the epiphyseal line. It has also been shown that these changes are not limited to the femur, but affect the tibia to a corresponding degree, so that in all cases of marked genu valgum the bones of the leg show a curvature as well as the femur. This is a point of great importance in treatment.

The condition is essentially due to a softening of the bones in young children, as well as in adolescents; in the former, the disease seems to be invariably of a rickety nature, whilst in young adults it is not improbable that this is also the case, although it is frequently impossible to find any rickety change, except the softening of the bone. Whether the disease in adolescence be due to rickets or not, the facts remain that, before it can occur, the bones must be soft enough to undergo bending, and, further, that the curvature occurs in the diaphysis immediately beyond the epiphyseal line. The changes in the femur consist of an outward bending at the lower end of the shaft, and an extension downwards of the diaphysis on the inner side, so that the epiphyseal line is altered in position and runs obliquely from without, downwards and inwards. In the tibia the change occurs in the diaphysis immediately below the epiphyseal line, and results in an outward curvature of the bone at that spot. In addition to the alterations in the immediate neighbourhood of the knee joint, certain other changes are also met with in this condition. In young children there is a tendency to hyper-extension of the joint, whilst the femur becomes rotated outwards, so that in walking the foot may be strongly everted. Flat foot is also a frequent accompaniment of the affection; in some cases it may be the exciting cause of the deformity, the alteration in the foot throwing the line of transmission of the weight of the body somewhat outwards. This diminishes the pressure on the inner part of the lower end of the femur, increases it on the outer side, and thus produces the curvature. The condition is generally bilateral, especially in young children, although it is generally worse in one leg than in the other.

TREATMENT.—In all rickety deformities, there is a tendency to spontaneous cure during the period of growth. The number of cases seen in adults is much smaller than that of the incipient ones seen in childhood; and many cases of slight deformity seen in adult life have been severe in childhood, a partial cure having taken place spontaneously. This is seen especially in the antero-posterior curves of the lower end of the tibia. In the rickety cases the bones are soft and bend, and, when the pressure is taken off, the tendency is for them to return to their normal shape. The bending may be produced either by the weight of the body when the child is standing or by the pressure due to a faulty position in children who have never walked.

The treatment therefore is partly general and partly local. The

general treatment must be directed to the removal of the cause which produces softening of the bones, and as, in the great majority of cases, this is rickets, the general treatment is that suitable for this affection; this is dealt with fully in Vol. II. and has been referred to in speaking of bow legs (see p. 363).

Local Treatment.—This will depend primarily upon the degree of the deformity. Up to a certain point, divergence of the legs is a condition that may be remedied comparatively easily by manipulations or apparatus; when it gets beyond that point, operative interference will be necessary. The first essential is to estimate the amount of deformity present, and this is best done by making the patient lie flat upon the back upon a table (not a yielding bed), and bringing the femora parallel with one another, with the patellæ looking directly forwards and the internal condyles separated by about half an inch. The distance between the internal malleoli is then measured, and those cases in which the distance between them does not exceed four inches are reckoned as mild ones which will get well without operation. When the interval is greater, the case may be reckoned as bad, and when it is six inches or more, operative interference will be required almost certainly before the deformity can be remedied. In these bad cases it will be noted that the patella no longer lies in the inter-condyloid notch, but is displaced outwards.

Cases in which the separation between the malleoli does not exceed an inch and a half.—Here there is every probability that the limbs will become straight without any special local treatment if the child be merely *kept from walking*, and if proper attention be paid to the general treatment. In deference to the wishes of friends, however, it is often wise to employ some local treatment. The limb may be massaged twice or thrice daily, and, during the process, the nurse should fix the thigh, and keep the knee extended, with the patella directed forwards and should then press the leg and foot gently inwards, and hold it in this position for a few minutes at a time. If this be carefully done, and the child prevented from walking, the deformity is most likely to disappear without further treatment, but the restriction as to walking must not be removed until the leg is practically straight and until the active period of rickets has passed, until in fact the child is four or five years old. It is often very difficult to prevent children from walking or crawling, and in some cases the general health may even suffer from a constant enforcement of the recumbent position. Under these circumstances, the rule may be relaxed to the following extent. The child may be allowed to go out into the sunshine and run about in the fresh air, but all walking or crawling about the house should be prohibited. As soon as he comes indoors he should be made to lie down, and the limbs should be rubbed, and the manipulations for the rectification of the deformity indicated above should be carried out.

When the child is allowed to be about during the day in the open air, the limb should be confined on a *splint* at night. In young children the best form is a Thomas's hip splint, in which an outside bar of iron connects the bands surrounding the thigh and leg (see Fig. 124). The splint is fixed on in the usual manner, the band around the thorax is fastened in position, and the trunk secured to the upper part of the splint by means of a flannel bandage. The thigh and leg are then fastened to the splint, and a broad piece of elastic webbing, well padded opposite the internal condyle, is passed around the knee and fastened to the outside iron band so as to draw the knee outwards. The knee must not be allowed to become flexed, or else the pressure is of no avail in remedying the deformity; care must likewise be taken to prevent rotation of the limb at the hip joint, which would render the outward pull upon the knee ineffectual. If, however, the leg and thigh be carefully bandaged to the splint before the elastic pressure is applied and if the bands of the splint be closely applied to the limb, this is not likely to occur. The splint should be removed in the morning, the limb washed and rubbed, the knee manipulated as before, and then the child may be allowed to crawl or play about in the sunshine.

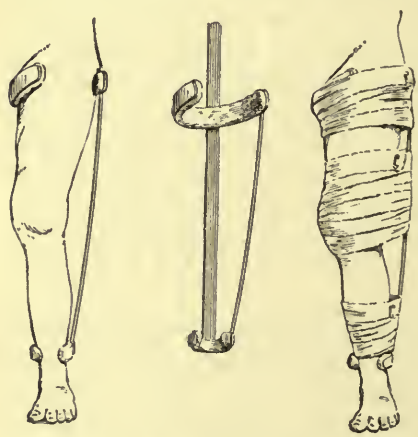


FIG. 124.—THOMAS'S HIP SPLINT, ADAPTED FOR USE IN GENU VALGUM. This is an ordinary Thomas's hip splint to which is added an outside iron bar joining the lateral wings above and below the knee. This iron may be prolonged below the foot so as to prevent the patient from walking. (Modified from *Hoffa*.)

Cases in which there is a separation of three or four inches between the malleoli.—The child should be kept off his feet, and should wear both day and night a *splint* designed to pull the knee outwards; the best is an external splint furnished with a band around the knee so applied as to pull the latter outwards. The chief disadvantage of a splint of this kind is that the child generally manages to rotate the leg outwards, and thus the band, which should bring the knee against the splint, is rendered ineffectual. Directly any outward rotation occurs, the band ceases to act upon the deformity, and simply bends the knee. Care should therefore be taken to see that, whatever splint be applied, this rotation is impossible. In young children the modification of Thomas's splint just described answers very well, and its action may be increased by prolonging the lower end of the iron bar three inches beyond the foot so as to prevent the child from walking.

A splint more suitable for older children is one in which there is an outside iron running from a pelvic band above to a slot in the heel of the boot below and which therefore prevents rotation. This necessitates the child wearing a boot both day and night, but this is no great objection. The knee is drawn outwards against the splint by means of a broad elastic sling (see Fig. 125).

Children are often allowed to walk wearing an apparatus which allows the knee joint to be bent and which, at the same time, is supposed to pull the knee outwards, but these splints are inefficient; they are too heavy for the weakly children who have to wear them, they are expensive and they do not exert much influence upon the deformity. Indeed, considering the satisfactory results of operative interference and the infinitesimal risk attaching to it, it is better to operate at once, when it is essential for the child's comfort that he should walk, and when he cannot do so without an apparatus of this kind.

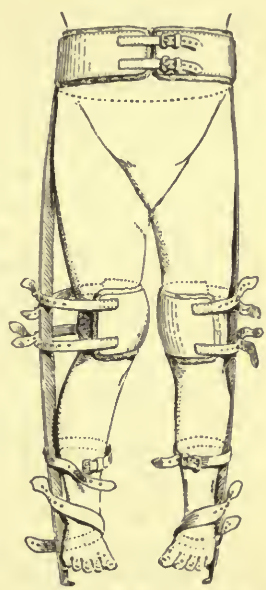


Fig. 125.—Splint for use in Genu Valgum. As this necessitates the wearing of a boot, it is more suitable for older children. It is more powerful and effectually prevents either flexion of the knee or rotation of the limb. (Modified from *Hoffa*.)

For patients to whom the expense of these forms of apparatus is prohibitive, a simple wooden splint yields very fair results. Two pieces of wood about two inches wide and long enough to extend from the groin to four inches below the sole are padded with tow or dressmaker's cotton-wool and covered with some firm fabric. One of these splints is fastened to the inner aspect of each limb with three of the straps and buckles usually used for carrying books; one strap is placed around the thigh at the upper part of the splint, a second just above the knee joint, and the third just above the ankle joint; the whole splint is then further secured by a flannel bandage applied from below upwards. The object of these splints is to prevent the child from walking or sitting with the legs curled up. This is usually quite sufficient to rectify the deformity in all but the severest cases, and the improvement is often very marked in a few weeks. If the splints do not restrain the child and he persists in walking on their ends, they may be made of unequal length.

The mechanical treatment of genu valgum, whether in a child or an adult, must be persisted in for a long time. It must not be given up until the active stage of rickets has passed off and the softening of the bones has disappeared; then there is not much chance of further increase in the deformity. The active period of rickets generally lasts until the child is about four years old, and the deformity will certainly recur if the apparatus be left off before this, even though it may have disappeared under treatment. Hence the treatment of knock-knee by rest and mechanical means must be persevered with until the child is at least four years old.

Cases in which the separation between the malleoli is greater than four inches, or in which, in spite of treatment by splints, marked separation exists after consolidation of the bones is complete.—In neither of these groups can much benefit be expected from mechanical treatment. As a rule it is found that the deformity remains in spite of prolonged mechanical treatment and much expenditure of time and money, and something further has to be done. There is no advantage in performing osteotomy while the bones are still soft if the patient be allowed to walk as soon as union has occurred, because the deformity will certainly recur. Hence, if osteotomy be done before the bones are firm, the patient must be kept off his feet after operation, and the treatment mentioned above adopted. At one time we were accustomed to defer operation until the rickety process was at an end, and consolidation of the bones had occurred; now, however, we begin the treatment with an osteotomy, and follow up the operation by the treatment appropriate for rickets (see p. 363). We did this originally because of the disinclination of parents to persist in the use of splints for a long period as a preliminary to operative treatment; as experience accumulated, however, we found that, on the whole, the period of treatment was shortened, since consolidation appears to occur more rapidly after operation, possibly as a result of the complete rest and better feeding. Should early operation not be employed, however, the treatment by splints, etc., described above, is carried out, partly with the view of correcting the deformity to some extent, but mainly in order to prevent it from becoming exaggerated. When the child has reached the age of four or five, and there is evidence that the bones are becoming firm, and when there is still a separation of more than four inches between the malleoli, it is useless to persevere with mechanical treatment, whilst operation furnishes a satisfactory and rapid cure.

In young adults mechanical measures seldom produce a satisfactory result, and it is sad to see these patients wearing cumbrous apparatus, and spending much time and money in attempts to get cured of a deformity that can be put right by a simple operation. In young adults suffering from genu valgum, therefore, we would advise operation in all cases in which the distance between the malleoli reaches four inches. It is not necessary to wait for complete consolidation in them. This generally occurs while the patient is lying in bed after the operation, and if care be taken not to allow the entire weight to be borne upon the limb too soon, and if suitable general treatment be adopted, there is little risk of the deformity recurring.

Osteotomy.—Various forms of operative procedure have been employed in these cases. Those in which the bone is broken without producing an external wound may be dismissed as unsuitable; it is impossible to gauge the amount of injury done, or the exact seat of the fracture produced, while there is not the least advantage in its use considering the great safety of the ordinary operation. Amongst the open operations, the following are most frequently performed: division of the femur just above the epiphyseal line (Macewen's operation); division of the tibia below the upper epiphysis; or division of both femur and tibia (see Fig. 126). From a consideration of the pathological changes present, it is evident that correction of the deformity in bad cases can only be obtained by the combined operation, and it may be laid down as a general rule that, when the interval between the malleoli is as much as six inches, this procedure should be adopted. In the less severe cases, however, good results may be obtained by dividing either of the bones

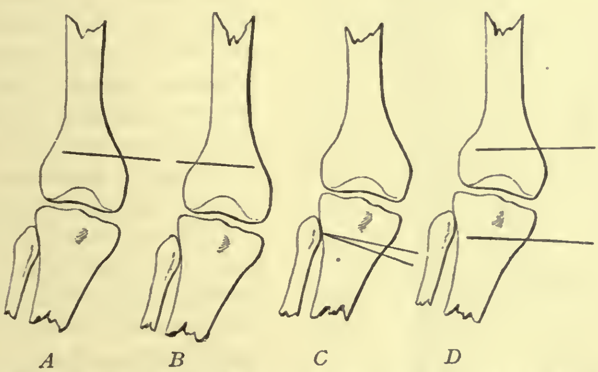


FIG. 126. VARIOUS FORMS OF OSTEOTOMY FOR GENU VALGUM. *A*. Macewen's operation. *B*. A similar operation, the section being made from the outer side instead of the inner. *C*. Division of the tibia below its upper epiphysis; this may either be linear or cuneiform. *D*. Division of both femur and tibia. (Modified from *Hoffa*.)

alone, and in practice it is immaterial whether the femur or the tibia be selected for division; probably a neater result is obtained by division of the tibia. The femur, however, is the bone most frequently divided, but this operation (Macewen's) often produces an unsightly bowing outwards and forwards in the lower third of the bone. The best plan is to have a radiogram of the limb taken in the position in which the amount of the deflection is estimated (*supra*), and this will show whether the femur, the tibia or both are affected and to what degree. The operation can then be decided upon in accordance with the information thus obtained.

Macewen's Osteotomy.—In dividing the femur by Macewen's method, the section is made from the inner side, and the deformity is rectified, partly by squeezing together the bone on the inner side of the femur, and partly by opening out an angle on the outer side. Some surgeons prefer to divide the bone partly across from the outer side, and then to convert this incision into an open angle by producing a greenstick fracture on the inner side ; this is certainly the easier operation, and the one that gives the better rectification at the time.

The patient lies upon the back, with the limb abducted and rotated outwards, and supported upon a firm sandbag. The hip and knee joint should both be flexed. The following description of the operation is in Macewen's own words:

' A sharp-pointed scalpel is introduced on the *inside* of the thigh at the point where the two following lines meet, one drawn transversely a finger's breadth above the superior tip of the *external* condyle, and a longitudinal one drawn half an inch in front of the adductor magnus tendon. The scalpel here penetrates at once to the bone, and a longitudinal incision is made, sufficient to admit the largest osteotome and the finger should the surgeon deem it necessary. Before withdrawing the scalpel, the largest osteotome is slipped by its side until it reaches the bone.

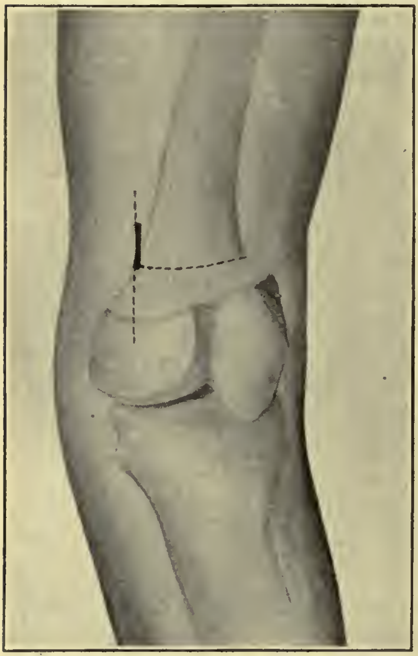


FIG. 127.—INCISION FOR MACEWEN'S OSTEOTOMY FOR GENU VALGUM. The thick line is the incision, the dotted lines the guides for fixing it.

' The scalpel is withdrawn, and the osteotome, which was introduced longitudinally, is now turned transversely in the direction required for the osseous incision. In turning the osteotome, too much pressure must not be exerted, lest the periosteum be scraped off. It is then convenient to pass the edge of the osteotome over the bone until it reaches the posterior internal border, when the entire cutting edge of the osteotome is applied, and the instrument is made to penetrate from behind forwards, and towards the outer side.

' After completing the incision in that direction, the osteotome is made to traverse the inner side of the bone, cutting it as it proceeds, until it has divided the uppermost portion of the internal border, when it is directed from before backwards, towards the outer posterior angle of the femur.

' In cutting on these lines, there is no fear of injuring the femoral artery. The bone may be divided without paying heed to this order of procedure, but it is better that the operator should have a definite plan in his mind, so that he may be certain as to what has been divided, and what remains to be done. The writer is persuaded that accidents have happened by not paying attention to this. In using the osteotome, the left hand, in which it is grasped, ought to give, after each impulse supplied by the mallet, a slight movement to the blade—not transversely to its axis, but longitudinally—so as to prevent any disposition to fixity which it might assume.

'After the inner portion of the bone is divided, a finer instrument may be slipped over the first, which is then withdrawn ; and even a third, if necessary, may take the place of the second, when the outer portion of the bone comes to be divided. Whether one or more osteotomes be used depends much on the resistance met with. If the tissue is yielding, one may suffice ; if hard or brittle, two or three will effect the division more easily, and with less risk of breaking or splitting the bones longitudinally. In the adult, the dense circumferential layer of bone resists the entrance of the osteotome at the outset, but several strokes cause the instrument to penetrate this superficial dense portion, when it will pass easily through the cancellated tissue.

'After a little experience, the surgeon recognises, by touch and sound, when the osteotome meets the hard layer on the outer aspect of the bone. If it be considered desirable to notch or penetrate this outer dense part of the bone, in doing so the osteotome ought to be grasped firmly by the left hand, the inner border of the hand resting on the limb, so as to check instantly any impetus which may be considered too great. It is better to snap or bend this layer than to cut it.

'When the instrument is to be altered in position, it ought not to be pulled out in the ordinary way, as it is then liable to be removed from the wound in the soft parts, as well as from the bone. Instead, let the left hand, with its inner border resting on the limb, grasp the instrument, while the thumb is pressed under the ridge afforded by the rounded head, and gently lever the osteotome outwards by an extension movement of the thumb (see Fig. 128). In this way the movement may be regulated with precision. It is desirable to complete all the work intended by the osteotome before removing it from the wound.

Fig. 128.—Method of holding Macewen's Osteotome. The instrument, grasped in the hand, is steadied by resting the ulnar border of the hand upon the thigh, and the thumb pressed beneath the head of the chisel serves to lever it gently out when it is desired to disengage it.

'When the operator thinks that the bone has been sufficiently divided, the osteotome is laid aside and a sponge saturated in 1 in 40 carbolised watery solution is placed over the wound. While the surgeon holds the sponge, he, at the same time, employs that hand as a fulcrum ; with the other he grasps the limb lower down, using it as a lever, and jerks if the bone be hard, or bends slowly if the bone be soft, in an inward direction, when the bone will snap or bend as the case may be.'

An Esmarch's bandage is not necessary during the operation, and no bleeding points require ligature. The line of section is everywhere above the ligaments of the joint, and no damage is likely to be done to the popliteal or femoral vessels, which are well out of the way of the osteotome, partly on account of the flexion of the knee, and partly by observing the directions given for the division of the bone. The only artery at all likely to be divided is the anastomotica magna, but that generally lies above and behind the incision. The superior internal articular artery is also avoided if the above directions be observed. It is rarely necessary to enlarge the wound in order to tie bleeding points ; there is, however, no objection to doing so, should it be necessary. Any vessel divided will generally stop bleeding, partly from its own contraction and partly as the result of pressure.

There are some points in the operations which deserve special attention. It is well to employ Macewen's osteotome (see Fig. 129), which differs from the ordinary chisel in that its cutting edge is bevelled on both sides instead of only on one ; a chisel is apt to jam in the bone instead of dividing it evenly. In young children the osseous section may be completed with a single osteotome, but in adults it is advisable to have two instruments of different size ; should the larger instrument become locked, it can be withdrawn and a smaller one slipped into its place and the section completed. The larger osteotome should be about two-thirds to three-quarters of an inch wide, the smaller about half an inch. When dividing the bone from the inner side, an endeavour must be made to keep the line of section parallel with that of the epiphysis, and therefore it should not be transverse to the long axis of the lower extremity. As a result of the displacement of the epiphyseal line, which is always present in genu valgum, the chisel will become buried in the external condyle if it be held transversely to the long axis of the limb, and may seriously damage the epiphyseal line.

FIG. 129.—MACEWEN'S OSTEOTOME.

Osteotomy through an Incision on the Outer Surface of Thigh.—Some surgeons prefer to divide the bone from the outer side of the limb, and we most frequently do this operation as it somewhat facilitates the rectification of the deformity. The incision should be made just above the external condyle, and, after all the structures have been divided down to the bone, the osteotome is slipped in along the blade of the knife and then turned transversely to the long axis of the femur. The line which the osteotome should follow runs obliquely downwards and inwards; it must not be directed far enough downwards to injure the epiphyseal line. It is generally best to make the osteotome cut through about half of the cancellous bone in the centre of the diaphysis first of all; then it should be withdrawn somewhat and made to divide the dense anterior surface, and finally it is made to divide the dense bone on the posterior aspect. All these incisions should be carried about half way through the bone, when the osteotome may be withdrawn, a sponge placed over the wound, and the remainder of the bone fractured by bending the leg inwards.

Osteotomy of the Tibia.—The best plan is to make a vertical incision commencing at the tubercle and running downwards along the crest for about an inch. This incision should be carried down to the bone, which is divided transversely with an osteotome, special care being taken to see that its inner side is cut through completely. The leg is then brought forcibly inwards, and, if sufficient rectification cannot be obtained in this way, the limb may be bent outwards again so as to fracture the outer side completely, when, on bringing the limb inwards once more, rectification can be obtained easily.

Osteotomy of the Femur and Tibia combined.—The best rectification is obtained by dividing both the tibia and the femur, and in bad cases this is necessary to ensure a satisfactory result. It is a matter of opinion whether the two bones should be divided simultaneously or at intervals. We are inclined to think that it is better to perform the operation in two stages; in the first the tibia is divided, and in the second, after the lapse of about six weeks, the femur. If the operations be performed in this order there is less danger at the second operation of re-fracturing the bone divided at the first, whilst a better rectification can be obtained if one bone be allowed to undergo consolidation before the second is divided.

After-treatment.—The small wound should be sutured, a dressing applied, the limb brought straight and put upon a splint. We use a roll of Gooch's splinting properly padded; the method of cutting it has already been referred to (see p. 369), but in the cases under consideration it is well to cut away a space for the heel so as to obviate all fear of pressure upon the os calcis. A large pad must be put over the internal condyle, and others over the outer side of the foot and ankle, so as to press the leg inwards. Another pad must be placed in front of the knee so as to prevent flexion of the joint (see Fig. 130). After the splint has been applied, the limb should be laid upon an inclined plane or a large pillow, so that the foot is well raised.

It is a common practice to apply a plaster of Paris bandage at this stage, but this has the disadvantage that great muscular wasting and laxity of the ligaments is commonly found when the bandage is removed.

It seems reasonable to treat an osteotomy as an ordinary fracture, and therefore ordinary splints will be found sufficient to keep the limbs steady after the wound has healed and the sutures have been removed, especially

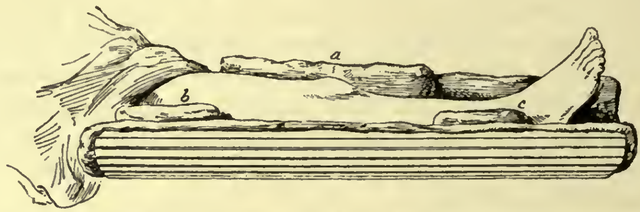


FIG. 130.—LIMB PUT UP IN SPLINT AFTER OSTEOTOMY FOR GENU VALGUM. The large pad (*a*) over the inner condyle on the one side, and the two thick ones (*b*) and (*c*) over the outer malleolus and the great trochanter respectively, on the other side, are shown. The large pad over the front of the knee to prevent flexion is not shown, while, for the sake of clearness, the dressing to the osteotomy wound has been omitted.

as the fractured surfaces are broad, the line of division transverse, and the periosteum often intact in places.

At the the end of ten days, the splints should be removed at least once daily for massage, and the knee joint should be moved passively at the end of a fortnight. In a month from the operation, the splints may be left off, and the child allowed to move the legs in bed. No walking, sitting or standing should be allowed for at least six weeks from the time of operation and only then should the rickety condition of the bone have passed away completely.

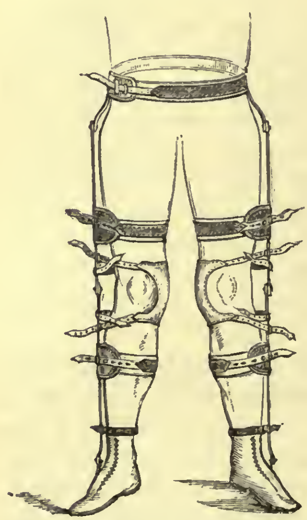


FIG. 131.—OUTSIDE IRONS FOR USE AFTER OPERATION FOR GENU VALGUM IN ADULTS. (*Erichsen.*)

When the osteotomy has been done upon a young adult in whom there is some doubt as to whether the bones have become consolidated, it is well for the patient after the operation to wear some form of apparatus to exert pressure upon the deformity ; this may consist of an outside iron fastened to the pelvis above and the heel of the boot below, and furnished with hinges opposite the hip, knee, and ankle joints (see Fig. 131) ; it is generally furnished with a band or sling to draw the knee outwards against the iron. This apparatus can be made of light material and should be worn for six months after the operation.

Those forms of genu valgum arising in connection with diseases other than rickets must have the primary cause treated on the lines appropriate for the treatment of the particular disease to which they are due. Should genu valgum occur after excision of the knee, the choice will lie between a fresh excision, or Macewen's operation ; in most cases the latter is a less severe and an equally satisfactory method. Should genu valgum occur in connection with infantile paralysis, the usefulness of the limb will have to be taken into consideration ; in some cases it may be found best to perform arthrodesis of the knee joint, so as to give the patient a firm and fixed point of support, whilst in others, in which the muscles are fairly healthy, a Macewen's operation, or any of the other operative procedures which we have mentioned, may be employed.

GENU VARUM.

This condition is the converse of the one just described, the lower part of the thigh and leg being bowed outwards so that the two limbs form an ellipse, or, in severe cases, almost a circle when the feet are placed together. The affection is usually due to rickets, although a somewhat similar deformity may occur after excision of the knee, from damage done to the inner side of the epiphyseal line ; it is also found in those who have habitually to assume certain positions, such as grooms, etc., who are constantly riding. If the patient be quite young when the deformity starts, it may attain a very marked degree ; when it originates in adult life, however, it is seldom serious enough to call for active treatment.

The patient usually walks with the toes turned in, and in bad cases the patella is dislocated inwards. The condition is generally bilateral, although sometimes children suffer from genu valgum on the one side and genu varum on the other. In these cases the deformity has been supposed to be due to the child always being carried upon one arm, so that the legs are pressed towards each other ; one limb is thus forced into a condition of varus, and the other into a condition of valgus.

TREATMENT.—In the milder cases splints should be applied to the inner side of the leg and the patient kept off his feet, while at the same time the general treatment suitable for rickets should be employed. In the severer cases, and in those in which the bones have become consolidated, osteotomy is necessary. Of the orthopædic apparatus the best is an **internal splint** which extends from the perineum to well beyond the foot, and is thickly padded opposite the ankle. This splint should project two inches at least below the toes when the latter are pointed, so as to prevent any possibility of the child walking upon tip-toe.

In the more advanced cases, and in those in which the active stage of rickets has passed off, operative interference is often desirable. Fracture of the bones by means of osteoclasts is not to be recommended, for the exact position and nature of the fracture cannot be accurately gauged and considerable damage may be done to the soft parts and to the ligaments of the knee joint. The only operative treatment to be recommended is **osteotomy**, and when the deformity is very marked, the bones may require to be divided at more than one spot. Division of the tibia is more important than division of the femur, and the bone should be cut through just below the knee. The fibula is bent or broken ; if it be too firm, it may be divided, but as a rule it yields readily.

The division of the tibia is best done by an *oblique osteotomy*. The bone is exposed by a vertical incision over the crest, and chiselled through obliquely from above downwards and backwards (see Fig. 122) ; it is then bent into position. It is often necessary also to divide the tibia lower down at the point of greatest curvature, and this may be done at the same operation. In very bad cases it may be even necessary to divide the bone a third time just above the ankle joint before the deformity can be rectified satisfactorily. The limb should be put up in Gooch's splint (see p. 382), and the after-treatment is similar to that in cases of genu valgum (see p. 381).

In bad cases it will also be found necessary to divide the femur at a later date. The osteotomy should be practised immediately above the lower end, but a second one may be required higher up the limb should the curvature be extreme. In bad cases several osteotomies may have to be done before the bones can be got satisfactorily straight ; Macewen has even done as many as ten in one patient. These bad cases, however, are much less common than they were. Two or even three osteotomies may be carried out at the same time, but, when several have to be performed, it is better to do them at intervals, so as to allow union to occur in one fracture before the next is made. Should the bone be divided in several places at the same time, there is a risk of the fragments not uniting properly, or if they do, it is difficult to insure that they unite in perfect position.

GENU RECURVATUM.

This condition is usually congenital and is comparatively rare ; in it the leg is hyper-extended at the knee-joint. It is met with in connection with congenital dislocation of the knee, and sometimes it occurs apparently from stretching of the posterior ligaments of the joint. It is occasionally met with as the result of infantile paralysis, and it may occur in connection with diseases in which the patients have been kept on their backs for a long time, for instance, long-standing tuberculous, hip-joint disease, or spinal disease. It is not at all uncommon in Charcot's disease.

TREATMENT.—The congenital cases are usually the only ones which call for vigorous treatment ; the deformity is seldom excessive in the others and can generally be rectified by putting up the limb for a prolonged period in a slightly flexed position and then employing an apparatus furnished with a hinge opposite the knee joint, fitted with a stop to prevent hyper-extension.

In the congenital cases, however, it is often very difficult to obtain a satisfactory result. In them the patella is often absent and in any case it is small. The treatment should be directed to straightening the knee first, and afterwards an attempt should be made to obtain flexion by the use of apparatus. A posterior splint is fixed to the thigh reaching down as far as the upper part of the popliteal space, and the limb is laid upon an inclined plane which terminates just above the knee. Extension by weight and pulley is then applied to the limb. At first the extension should be in the line of the thigh, so as merely to stretch the ligaments, but in two or three weeks the pulley may be gradually lowered so as to produce an increasing amount of flexion, the thigh remaining fixed in the elevated position.

In very bad cases all attempts to obtain flexion may fail; they must not be too energetic, as otherwise a true anterior dislocation of the leg may occur. When the muscles and ligaments are shortened, only operative interference will overcome the trouble; this consists in lengthening the quadriceps extensor through a curved incision with its convexity upwards about four inches above the knee joint. A flap is turned down, and the muscle is divided in a V-shaped or zig-zag manner, by the method described for lengthening muscles (see Vol. II.). At the same time all tense fibrous structures interfering with flexion of the limb are divided by a tenotomy knife.

The treatment is a prolonged one, and when the patient begins to walk, he must be fitted with an apparatus designed to prevent over-extension at the knee joint. This has irons running down both sides of the thigh and leg, fastened to a pelvic band above and the heel of the boot below, and has joints opposite the hip, knee and ankle joints; the knee joint hinge is furnished with a stop to prevent over-extension.

CHAPTER XIX.

CURVATURES OF THE NECK OF THE FEMUR.

CERTAIN deformities result from alterations in the normal curvatures of the neck of the femur and are generally divided into two groups called respectively Coxa Vara and Coxa Valga.

COXA VARA.

CAUSES.—This deformity is met with at two periods of life; in infants or young children of three or four and in young adults between the ages of thirteen and eighteen. It is said that the affection is sometimes congenital. There is considerable uncertainty as to the exact etiology of the disease; it is possible that the deformity occurs in infants as the result of some malposition *in utero*, as it is difficult to account for it on the ground of any faulty position assumed by the child while lying down or being carried in arms. There is no doubt, however, that in the great majority of cases the deformity in young children results from softening of the bones due to *rickets*. It is also highly probable that a large number of cases in young adults owe their origin to the condition that goes by the name of '*rachitis adolescentium*.' In some of the adult cases, however, no signs of rickets are to be traced, and these have been attributed to rheumatoid arthritis, to osteitis, or to other causes; the affection may certainly supervene upon a mild attack of rheumatism. The deformity in adults generally occurs in those whose occupations involve continuous and prolonged standing or carrying of heavy weights. By some it is held that the disease is more common in young adults than in infants, but this is very doubtful; certainly, since our attention has been directed to the point, we have found a large number of cases in young rickety children. Indeed careful examination of rickety children with knock-knees will show a certain amount of curvature of the neck of the femur in the majority of cases. This can possibly be explained as a deformity compensatory to the knock-knees, in which condition there is a lateral curve of the whole limb with its convexity inwards. Such a deformity is much more inconvenient to the patient than an antero-posterior curve, and hence the limb tends to become rotated outwards. The rotation is at first simply due to muscular action, but, being maintained, the soft bone bends and a definite curvature of the neck of the femur follows. Alterations in the neck of the femur are sometimes met with after fractures in that region and are then termed 'traumatic coxa vara.' These cases are dealt with in connection with fractures (see Vol. II.).

PATHOLOGICAL CHANGES.—The direction of the abnormal curvature in the neck of the femur is not invariably the same, but it is generally such as to produce outward rotation of the lower limb. The angle formed by the neck with the shaft of the femur is always diminished, and the great trochanter is therefore elevated and the limb shortened. Generally also there is a bowing forward of the neck of the bone so that the trochanter is thrown too far backwards and external rotation of the limb results (see Fig. 132).

FIG. 132.—COXA VARA. Showing the typical deformity of the neck of the femur.

As seen in young children, the affection generally has the following characters : the trochanter is raised above Nélaton's line and there is marked outward rotation of the whole lower extremity. The limits through which the limb can be rotated are smaller than normal, for, while the range of outward rotation is considerably increased, that of internal rotation is proportionately more diminished. The result is that, when the child lies flat upon the bed and the limb is rotated inwards as far as it will go, the patella at best can only be made to look directly forwards and cannot be directed inwards at all ; indeed, in the severe cases, even this amount of inward rotation cannot be effected. On the other hand, the limb can be rotated outwards until the patella looks almost directly backwards. There is also considerable alteration in the range of adduction and abduction ; when outward rotation is marked, abduction to the normal extent is impossible, and the power of flexion may also be interfered with unless the limb be in the abducted position. If, however, the limb be abducted and rotated outwards, full flexion can be obtained, and the patient may actually be able to make the feet meet behind the head. The feet are frequently kept rotated outwards at right angles to the antero-posterior plane of the body with the knees somewhat bent, and the child can neither walk nor stand upright.

When the affection is met with in adults, in addition to the deformity, it is common to find complaints of a sensation of fatigue in the early stages of the affection, and of pain about the hip-joint, which becomes more severe as the disease progresses. Later on, the patient begins to limp, and ultimately he experiences difficulty in stooping, and notices that the movements of the hip-joint are restricted and abnormal. If the case be left to itself the final result is that the bone undergoes consolidation in the faulty position and the deformity is thus permanent; the patient is compelled to limp about with the feet turned out and suffers considerably from interference with the movement of the hip-joint.

TREATMENT.—**In Young Children.**—While the child is quite young and the bones are very soft, an attempt should be made to rectify the abnormal curves by means of extension and manipulation. Most of the milder cases in young children can be cured by simple extension, the leg being put up in a position of moderate abduction. Indeed rest in bed for several weeks will sometimes produce great improvement, without the use of any extension.

Mechanical.—It is not easy to devise an apparatus to maintain steady pressure upon the bone in a direction such as to restore the normal curvature of its neck, but the following arrangement (see Fig. 133) has proved very successful in our hands. A strip of malleable iron of suitable length is applied along the back of each lower limb. Each strip should reach from the centre of the thigh above and should be accurately adapted to the middle line of the back of the thigh and the calf, being bent round behind the heel and up along the centre of the sole, projecting for several inches beyond the tips of the toes and ending there in a hook (*a*). Opposite the under surface of each heel there is a pivot (*b*) over which passes the perforated end of a transverse bar (*c*) which can be lengthened or shortened at will, and from the centre of which extension of both

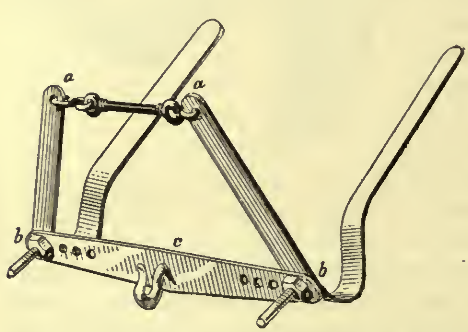


FIG. 133.—EXTENSION APPARATUS FOR COXA VARA. The anterior ends of the foot-pieces are approximated by the india-rubber springs attached to the hooks *a*. The abduction is regulated by the transverse bar; the limbs can be approximated or separated by passing the pivots *b* through the different holes in the transverse bar *c*. These holes are large enough to allow the limb to rotate inwards easily when in the abducted position. Extension is made from the hook in the centre of the transverse bar.

limbs can be made simultaneously by a weight and pulley at the end of the bed. This transverse bar is designed to keep the limbs in the requisite position of abduction during extension, while its extremities provide fixed points about which the limbs can be rotated so as to overcome the rotation outwards. This is done by fastening to the hooks (*a*) an elastic door spring of suitable strength which thus pulls the toes together while the heels remain separated by the transverse bar (*c*). The apparatus must be firmly fastened to the limb by including it in the folds of a plaster of Paris bandage (see Fig. 134). The weight used for extension should be

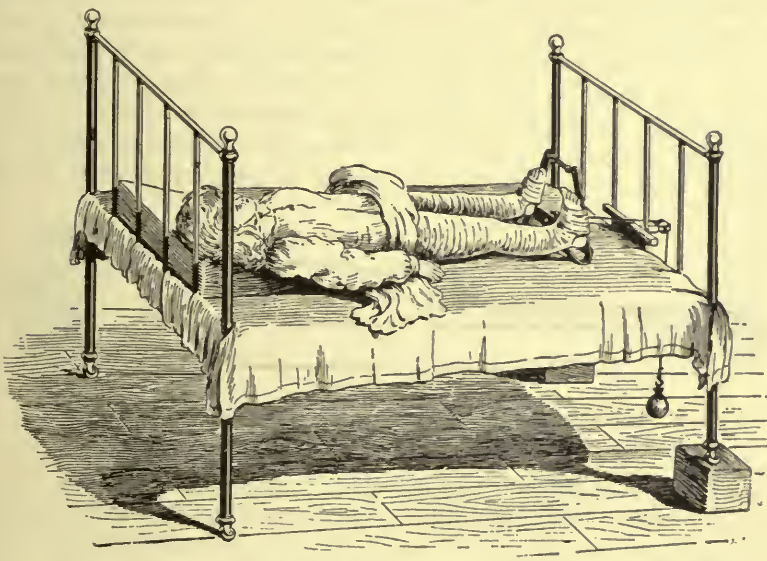


FIG. 134. EXTENSION APPARATUS FOR COXA VARA APPLIED. The iron bars are incorporated in the layers of a plaster of Paris bandage so that the limbs are immovably fixed to them. Extension is made with the limbs abducted and well rotated inwards. The extension is applied in a somewhat upward direction to avoid the friction caused by the heavy splint lying flat on the bed.

three or four pounds to commence with, according to the size of the child; it may be increased later.

The apparatus should be renewed about once a fortnight, as it is liable to become soiled with urine. When this is done, the limb should be massaged, and it is well to practise repeated inversion, flexion, and adduction, before the splint is re-applied.

The results obtained by this method are often surprisingly good and very rapid. It would therefore appear that at any rate some part of the deformity and incapacity from which the child suffers must be due to muscular action, for it is obvious that extension and traction could not produce any profound change in the curvatures of the neck in so short a time. The extreme outward rotation may disappear in three weeks, although of course the elevation of the trochanter still remains, and will only be rectified very gradually as growth proceeds and the rickety condition disappears.

The elastic traction should be kept up until all tendency to reproduction of the deformity as the child lies in bed has disappeared. This will probably be in from four to six weeks in early cases. The subsequent treatment should be that appropriate for rickets (see p. 363), and special care must be taken to prevent the limbs habitually assuming their old faulty position.

A simpler form of apparatus is shown in Fig. 135. Two splints, each two and a half inches wide, and long enough to reach from the axilla to just beyond the heel are prepared. Opposite to the trochanter, a piece of wood the same width as the long splint and about six inches long is fixed to each splint at right angles, the free ends being perforated by a half-inch hole. Opposite the trochanters, just above the point where the shorter pieces are attached, the two splints are joined together by a broad strip of webbing which serves to keep them from coming

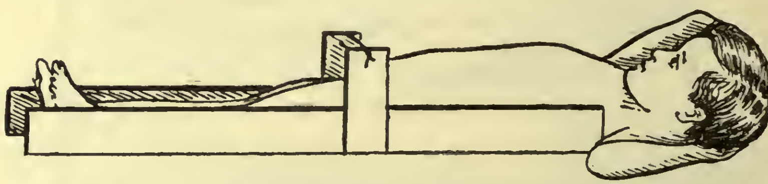


Fig. 135.—Splint for use in Coxa Vara. For the sake of clearness the bandages are omitted.

forward, but is sufficiently loose to allow rotation inward of the whole apparatus. The splints are fixed firmly to the legs by a spiral band of strapping and bandages; to the trunk they are fastened merely by a loose binder. A piece of elastic or string is threaded through the holes at the ends of the short vertical pieces, and the whole leg is rotated inward by tightening this. An improvement of fifteen to twenty degrees can be obtained in a fortnight.

Operative.—Should no improvement result after a careful and prolonged trial of this method, some form of operative procedure designed to overcome the excessive outward rotation will have to be considered. Operative treatment, however, is rarely called for in young children, as the methods advocated above will certainly suffice for all but very neglected cases, and there will be fewer of these now that the nature of the affection is widely recognised. It may be necessary, however, in young adults.

Sub-trochanteric Division of the Femur.—In a bad case in a child we obtained a good result by dividing the femur below the trochanters through a vertical incision four inches long carried down to the bone from just below the upper border of the great trochanter. The bone was cleared with a rugine and divided transversely just below the lesser trochanter with a fine-bladed saw. The great trochanter was then pushed as far forwards as it would go, while the leg and the lower part of the femur were rotated inwards until the limb was in a position of complete internal rotation. The two portions of the bone were then surrounded by a collar of sheet aluminium fastened on by tacks and the wound was closed without a drainage tube. The limb was put in a trough of Gooch's splinting which was then raised on an inclined plane and rotated inwards so as to maintain the leg in a position of internal rotation. The recently introduced plates and screws which are described in connection with the mechanical fixation of fractures (see Vol. II.) would probably be preferred for the purposes of fixation nowadays (see Fig. 136). The after-treatment is the same as for those cases.

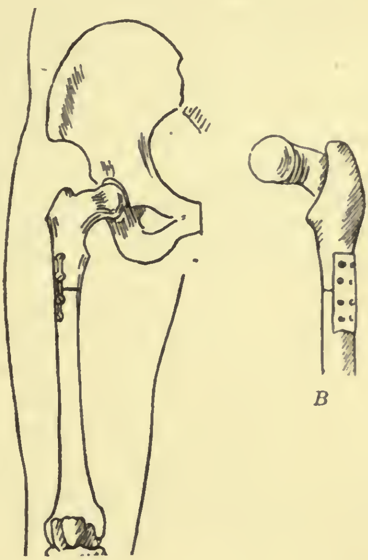


FIG. 136.—SUB-TROCHANTERIC OSTEOTOMY FOR COXA VARA. In *A*, the bones are united by a bone-plate; in *B*, by an aluminium collar.

The rationale of this proceeding is that the hip joint is left undisturbed, whilst the rotation of the foot, as far as walking is concerned, is completely corrected, for although the trochanter does not rotate as far forwards as it should, the foot is in its normal position when the femur is rotated inwards as far as it can go. On the other hand, when the trochanter is rotated outwards to its extreme limit, the foot is usually in the position of normal external rotation.

In young adults the best treatment is by Thomas's hip-splint applied as recommended for hip disease (see Vol. III.). The splint requires to be kept on until all tenderness and pain have disappeared. The patient's general condition should receive careful attention, and hygienic measures must be insisted on as for tuberculosis. Oleum phosphoratum in minim doses, combined with emulsion of cod liver oil, is valuable.

When the bones have consolidated, an operation must be undertaken if the degree of deformity be such that the patient is unable to walk unaided. In a case which has resisted palliative treatment and in which ossification is complete a sub-trochanteric osteotomy (*vide supra*) will suffice. This is preferable to excision of a wedge from the neck of the femur as proposed by Kraske, which is extremely difficult to perform; it is still more difficult to fix the fragments afterwards, and get a good movable joint.

COXA VALGA.

In this deformity the head of the femur is displaced upwards, and the shaft is abducted ; in other words there is an increase in the angle made by the neck of the femur with the shaft. Associated with this alteration in the angle there may be a curvature backwards or forwards of the neck. The deformity is present to some extent in the majority of cases of congenital dislocation of the hip ; it is then probably secondary to dislocation forwards of the head of the bone. It has also been described in association with infantile palsy, as a result of rickets, secondary to genu valgum, and as a sequel of some forms of fracture of the neck of the femur. The signs are abduction and external rotation of the limb, with limitation of adduction and inversion. In unilateral cases, there is an increased length of the limb. There is flattening over the great trochanter, which may be below the level of Nélaton's line. The outer aspect of the trochanter may also be directed backwards. Very little is really known either of the pathology or the treatment of this affection ; we shall therefore not go further into the matter at present.

CHAPTER XX.

CONGENITAL DISLOCATION OF THE HIP.

THE hip joint is not infrequently the subject of congenital dislocation, and the affection is much more commonly met with in females than in males. The deformity may be unilateral or bilateral; probably it is more often bilateral.

PATHOLOGY.—The condition commonly met with in children under the age of puberty is displacement of the head of the femur upwards from the acetabulum so that it lies just beneath the anterior superior spine of the ilium. As the child gets older and heavier and walks more, the head passes backwards, until eventually there is a typical dislocation on the dorsum ilii. In the early cases there may be very little lordosis as long as the head of the bone lies immediately above the acetabulum; as the head passes on to the dorsum the lordosis becomes well marked. The head of the bone is practically unaltered in early cases, but in long-standing cases (after seven years) it may be flattened and mushroom-like. The acetabulum is always present but is smaller than normal, and is often almost entirely masked by the anterior part of the capsule of the joint which is tightly stretched across it and bound down by the tendon of the psoas, so that only a small slit-like aperture is left leading into the acetabular cavity. The neck of the bone is invariably rotated forwards, and this is an important point to bear in mind during treatment. The ligamentum teres is represented by a thin elongated cord, or is entirely absent.

When the dislocation has lasted for more than a few months, contraction occurs in the muscles surrounding the joint and not only prevents the head of the femur from being brought into position but also interferes with walking. The muscles most affected are the adductors which draw the affected limb inwards; in extreme bilateral cases a condition of cross-legged deformity may be produced. There is always some lordosis which increases as the child grows older and is most apparent on standing. In unilateral cases there is generally some scoliosis also.

In the early stages it is generally possible, at any rate during the first two or three years of life, to bring the head of the bone nearly, if not quite, down to its normal level by steady extension, and while doing this it is often possible to feel a definite click as the head comes down over the edge of the acetabulum. If the pelvis be fixed with one hand and the affected limb grasped with the other, the head of the femur can be moved up and down in a vertical direction over the side of the pelvis in young children. In later life, when the upward dislocation has become converted into a dorsal one, this vertical movement is not so free. The gait is marked by a peculiar waddling movement which is due to the sliding of the head of the femur over the surface of the innominate bone, and in addition there is lordosis and adduction of the affected thigh. The condition is of considerable gravity on account of the increasing difficulty in walking as age advances.

TREATMENT.—It is important to discriminate between the cases in which good results may be expected from treatment and those in which nothing can be done. There are some in which the lordosis is so slight and the waddling gait so little marked that it is inadvisable to undertake any treatment, especially if the deformity be bilateral. Similarly, treatment does not do much good when the displacement is considerable and the contraction of the soft parts is so great that there is little chance of getting the head of the bone down to the acetabulum. Those cases are best suited for treatment in which the deformity is unilateral, and there is such free mobility of the head that it is apparently not difficult to get it down to the acetabulum. Surgical measures should always be adopted in cases of dorsal displacement ; there is then at least the certainty of converting the dorsal displacement into an anterior one, and this may be made stable in many cases by a prolonged use of the plaster of Paris bandage recommended below.

There are two methods of treatment which give fairly good results, and for which we are indebted to the work of foreign surgeons, chiefly Lorenz, Hoffa, and Paci. The object is to replace the head of the bone in the rudimentary acetabulum either with or without an open operation first of all, and then gradually to form an efficient hip-joint. Although both these methods show a distinct improvement upon the older ones, they nevertheless frequently fail to give a perfect result. They are chiefly applicable to children between the ages of two and seven years ; before and after that time little can be done beyond the employment of apparatus. It may be possible to obtain a good result by operative means in children over seven years of age, but it is rare.

We shall describe first the treatment for cases in early infancy before the child has learned to walk. After this will come the non-operative method which is now carried out chiefly by Lorenz's method and which is most suitable for children who are three or four years old and have learnt to walk. Finally we shall describe the method by open operation which may either be employed when the non-operative one has failed or when the child is too old for it to be likely to succeed.

In Infancy.—The existence of the deformity is often recognised in infancy; the nurse calls the doctor's attention to something wrong in the hip-joint and the existence of a congenital dislocation is recognised. A radiogram will show at once whether there be a dislocation present or not. The clear space corresponding to the Y-cartilage in the acetabulum is always seen, and this should be opposite to the equator of the head of the femur. If there be a dislocation the head is above this line. The question then arises as to what steps are to be taken at this early age, since an essential point in the methods described below is that the patient shall be able to walk, and therefore it is seldom advisable, or indeed possible, to practise them until the child is two and a half or three years old. Some treatment, however, should be undertaken as soon as the nature of the case is recognised. *Massage and manipulations* should be practised during the time that must elapse before the child is of a fit age for the treatment recommended below. In early infancy there is no difficulty in bringing the head of the bone down to its proper level and this should be done several times daily by the nurse, and will serve to prevent shortening of the muscles. When the head of the bone has been pushed well down, gentle outward rotation, with abduction and hyper-extension of the limb, may be carried out. If this treatment be persisted in, it should facilitate the subsequent reduction of the deformity. Some surgeons prefer to put the child up in an extension apparatus, but this is not so satisfactory as the method we have described, because it is impossible to fix an infant up properly, and moreover extension does not stretch the muscles in the various directions that are necessary.

Lorenz's Non-Operative Method.—The object of this procedure is to bring the head of the femur down into position over the rudimentary acetabulum, to keep it there, and then to cause it to enlarge and deepen the rudimentary cavity by pressure and friction as the child walks, until a more normal acetabulum is formed. The first essential for success is that the patient should be young; at the same time it is of primary importance that the child should have learnt to walk and also that it should be sufficiently cleanly in its habits to avoid soiling the bandages. After the child has reached the age of seven years, the chance of bringing the head of the femur successfully down over the acetabulum without an open operation is very slight, because of the shortening of the muscles, ligaments, and soft tissues generally, and therefore, if non-operative treatment is to succeed, it should be employed before this age. In young children it is often easy to get the head of the bone into position over the acetabulum without an open operation, but attempts to push it into the small slit that leads into the acetabulum generally fail, partly because of the tension on the front part of the capsule, and partly because the head of the femur is too large to pass through the slit. If, however, the anterior part of the capsule be stretched or divided, the head of the bone will go into the rudimentary acetabulum and then the limb can be immobilised in that position. The following are the stages of the procedure as practised by Lorenz.

First of all the head must be brought down to the level of the acetabulum, next the adductors must be so stretched that they are incapable of reproducing the deformity, then the capsule must be detached from the front of the acetabulum and finally the head of the bone must be brought

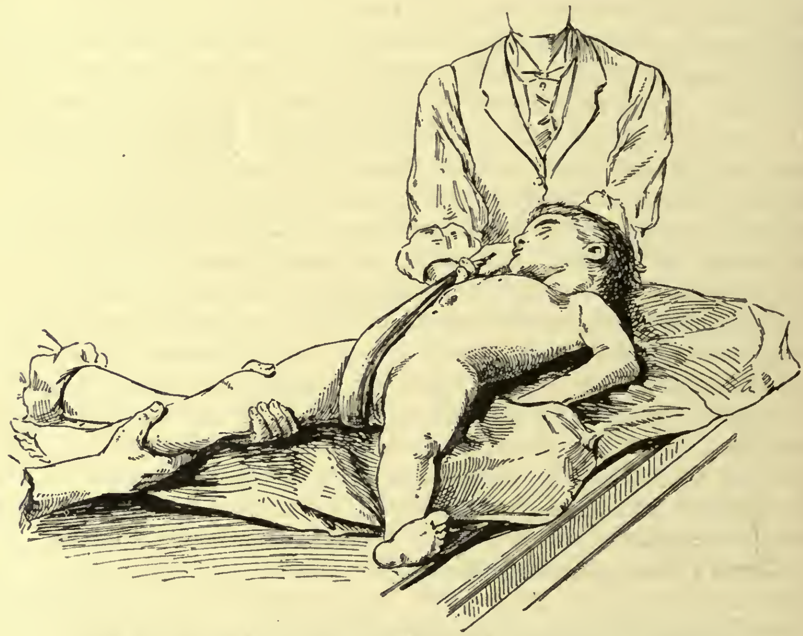


Fig. 137.—Lorenz's Non-operative Method for Congenital Dislocation of the Hip. *First Stage.* While an assistant makes counter-extension by a perineal band, the surgeon forcibly pulls down the head of the bone until it is opposite the acetabulum. The traction is made outwards as well as downwards, so as to stretch the adductors.

over the rudimentary acetabulum, where it is kept until the head has enlarged it sufficiently to establish a stable joint on which the patient may walk without the dislocation recurring. We shall describe the treatment of a case of unilateral dislocation; although the steps of the treatment are similar for both unilateral and bilateral forms, the former condition is much more easy to treat because the patient possesses one sound limb on which to support himself when walking becomes necessary.

The child is anæsthetised, and forcible extension is made upon the thigh so as to bring the trochanter down to the level of Nélaton's line, while counter-extension is exerted by a well-padded perineal band. The more important part of the procedure consists in over-stretching or actually rupturing the shortened adductors, and thereby paralysing them and rendering them unable to reproduce the deformity. In order to do this effectually, the pelvis is steadied by an assistant who presses upon the anterior superior iliac spine on the sound side while the surgeon attempts to abduct the affected limb to a full right angle. The adductors resist this, and their resistance is overcome by striking the tense muscles repeatedly with the ulnar border of the hand while the extremest abduction possible is maintained. The stretched and contused adductors at last give way and allow full abduction of the limb to be obtained; considerable subcutaneous effusion of blood usually follows this. Finally all the muscles around the joint are stretched by exaggerating the movements of the limb in all directions, especially in that of over-extension.

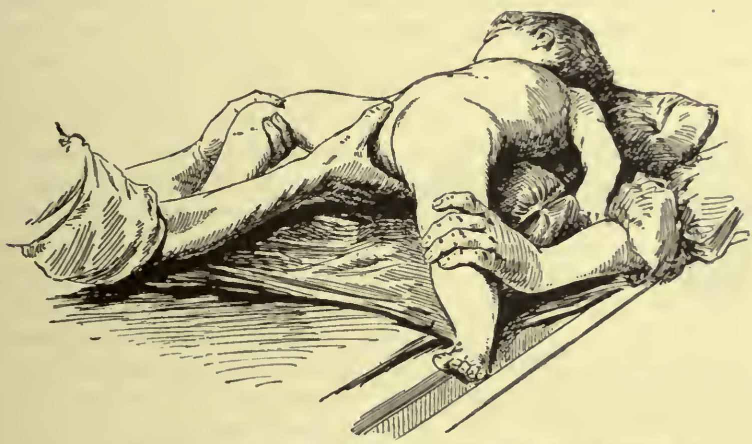


FIG. 138. LORENZ'S NON-OPERATIVE METHOD FOR CONGENITAL DISLOCATION OF THE HIP. *Second Stage.* The limb is rotated outwards and abducted to its fullest degree after the head has been brought down over the acetabulum. The adductors require much kneading by the surgeon's fingers, as is shown in the drawing. The hip joint is also fully extended.

After satisfactory stretching of the muscles has been obtained, the next step is to try to detach the capsule from the front of the joint. This is done by the ordinary manipulations for dislocation of the hip frequently repeated; at first complete flexion of the limb with rotation inwards, followed by abduction, rotation outwards, and extension. It is the latter manipulations which aim at getting the soft material peeled off the surface of the acetabulum.

The head of the bone is got into the acetabulum by the following manipulations. An assistant steadies the pelvis, and the surgeon, flexing the hip joint to a right angle, makes traction upon the thigh in its long axis, while at the same time he presses the great trochanter inwards against the pelvis. When the limit of extension has been reached, the limb is carried outwards through nearly 90°, so that the femur lies nearly flat upon the table and at right angles to the median plane of the body. By this manœuvre the head of the femur is made to pass over the dorsal lip of the acetabulum—an event usually marked by an appreciable click —and rests over or actually in the acetabular cavity into which it is firmly jammed by carrying the limb outwards through a right angle. Owing to the fact that the head and neck of the bone are usually deflected somewhat forwards, it will be necessary to rotate the limb a little inwards, in order to get the position of maximum stability ; the limb will therefore be parallel to the horizontal plane of the body but at right angles to the median vertical one, and in addition it will be slightly rotated inwards.

After-Treatment—In this position of maximum stability the limb is put up in a plaster of Paris spica, which, according to Lorenz, does not take in the knee. In this the child is kept for four or five months, and is allowed to crawl about as best he may; at the end of this time, another spica is applied, after the limb has been brought down to a position of slight abduction and a little flexion. It is somewhat difficult to apply the spica while keeping the head of the bone firmly in place on an ordinary operating table. Lorenz has introduced a special sacral rest upon which the pelvis is supported, and this is excellent for the purpose and greatly simplifies the proceedings.

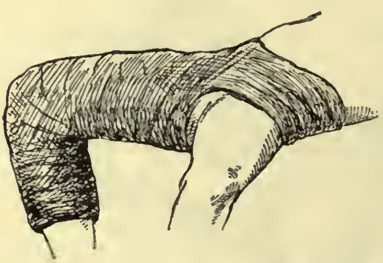


Fig. 139.—Lorenz's Non-operative Method for Congenital Dislocation of the Hip. *Third Stage.* The limit of stability of the joint having been found in the last stage, the lower extremity is put up in the above position, the knee being flexed.

In this apparatus the child is encouraged to walk as much as possible, in order to press the head of the femur against the acetabulum and so deepen it. The treatment lasts for eight to ten months.

We are accustomed to depart slightly from this procedure. In the first place the serious troubles following the rough handling of the muscles, such as hæmatoma, abscess, cellulitis, etc., lead us to prefer subcutaneous division of the adductors close to their origin from the pelvis. This we do about a week before the reduction, and the manipulations are rendered easier thereby, and at the same time less likely to be followed by complications. In the second place we invariably include the knee in the first plaster. It seems to us that, until the parts are sufficiently adapted to their new position to keep the head of the bone in place unaided, it is essential to avoid rotation of the femur under the plaster, which can occur with the greatest ease unless the knee be included.

The child is not allowed to come round from the anæsthetic until the plaster casing has set ; it is well to strengthen the latter with strands of tow impregnated with plaster cream opposite the points of greatest strain. At first the child complains a good deal, but the pain usually disappears in two or three days. It is well to have a radiogram taken at this stage through the plaster casing, so as to ascertain whether the head of the bone remains in place. Should it have slipped out of position, the displacement must be rectified and the limb put up as before. The plaster case is removed in ten or twelve weeks: should it become sodden with urine or fæces, as not infrequently happens in young female children, the apparatus must be re-applied, but no change in the position of the limb should be made until after the lapse of that time. If there be any doubt as to the recurrence of the deformity, a radiogram will settle the question. During the time that the limb is in the first plaster casing the parts are becoming consolidated after the manipulations to which they have been subjected, and the tissues around the joint contract, so that when the casing is removed, the limb often retains its abducted position spontaneously. The abduction is now gradually diminished as long as the head of the bone does not slip out of position. Directly a position reached in which the head of the bone is becoming unstable, the limb is abducted a little more and a little flexed, and the plaster of Paris spica is re-applied. The main difference between the new position and the old one is that the degree of abduction is now less.

The patient is now taught to walk with the limb abducted. Every time the weight is borne upon the affected limb, the head of the bone is pressed against the acetabulum, and the more the child stands upon the leg the longer is this pressure maintained, and the more quickly is the acetabulum increased in depth. The plaster should not be continued below the knee at the second sitting as the leg is thus left free for movement, which both helps to maintain its nutrition, and also facilitates walking; the child soon learns to walk without assistance. A radiogram will show whether the dislocation has recurred, and, if it has, the apparatus should be taken off and the head of the bone got into position again.

A very easy and expeditious way of removing plaster of Paris casings is by means of Gigli's wire saw. Before the casing is applied, a piece of string dipped in oil or melted beeswax (to prevent adhesion to the plaster and subsequent fraying) is laid along the limb between the boric lint and the plaster bandage and left there. When the plaster is to be removed, one end of the wire saw is attached to one end of the string, the other end of the latter is pulled upon, and the string is withdrawn, leaving the saw in place beneath the plaster. The handles are then hooked on to the saw, and the casing can be cut through in a few seconds. If the casing be a very stout one, two pieces of string, one along each side of the limb, may be used instead of one along the centre.

After about eight to ten months no further apparatus is necessary, the soft parts having become sufficiently shortened through their prolonged rest in the abducted position to keep the head of the bone in place. Indeed, it is common to find that attempts to adduct the limb fully cause pain, and the patient naturally keeps the limb somewhat abducted. The head of the bone will usually keep in position without the assistance of any apparatus.

Treatment must now be directed to strengthening the muscles about the hip joint, especially the abductors, by massage and by the use of suitable exercises against resistance. The patient should attempt to abduct the limb, whilst the nurse opposes the movement ; this strengthens the abductors, which are the main factors in keeping the parts in position. Adduction can be guarded against by raising the heel of the boot on the sound side about one inch ; in time this may be reduced, and ultimately it may be done away with.

In *bilateral dislocation* the outlook is not favourable, but treatment is carried out simultaneously and in a similar manner in the two legs. At the end of about twelve weeks abduction may be so far reduced that the patient can use both legs in walking.

Operative Methods.—When a child has reached the age of seven before it comes under observation, the manipulative methods almost uniformly fail, and the only chance of benefit lies in the performance of an open operation ; experience has shown us that, provided the articular cartilage be not removed, considerable improvement is often obtained, and, even when the surgeon fails to get the head of the bone into the acetabulum; considerable benefit will be obtained, since the flexion and adduction of the limb can be overcome, and fixation of the head of the bone can be effected.

The operation we practise is done as follows.[1] The patient is put under an anæsthetic, and any unduly tense structures are divided subcutaneously; those generally requiring division are the adductors close to their origin, the fascia lata of the thigh, and sometimes the muscles attached to the anterior superior iliac spine, and even in bad cases the hamstrings. A week or ten days later, under full anæsthesia, manipulations designed to stretch the parts are first practised, and then an incision is made downwards and slightly inwards from just beneath the anterior superior iliac spine, over the interval between the sartorius and the tensor fasciæ femoris ; in order to facilitate access to the deeper structures the upper end of this incision may be curved out along the iliac crest, and the tensor fasciæ femoris detached from the bone (see Fig. 140). This incision divides nothing of importance, and gives satisfactory access to the joint. The head and neck of the bone are exposed, and the capsule of the hip joint is slit up from the anterior inter-trochanteric line to the rim of the acetabulum. The finger is passed into the joint and feels for the slit leading into the true acetabular cavity. If this be too small to admit the head of the bone, the front portion of the capsule is detached from the rim of the acetabulum sufficiently to allow the head to pass through it into position.

[1] See *Brit. Med. Journn.*, 1903, ii. p. 457.

An attempt is next made to get the head of the bone into position by suitable manipulations ; these will be generally similar to those practised in the non-operative method. The surgeon has the advantage in the open method, however, that he is able to see when the head of the bone goes into place, which it usually does with a definite snap, just as it does in traumatic dislocations that are reduced. When the head has been got into place, the position of maximum stability is found, and the limb is kept in that position until the wound has been closed and a plaster of Paris spica has been applied. This position is generally similar to that in the non-operative method, viz., full abduction, slight extension, and inward rotation, but it varies very much in individual cases and depends to a large extent upon the deflection forwards of the neck that has taken place. There is never any doubt as to the right position, however, as it is the only one in which the head remains in the acetabulum.

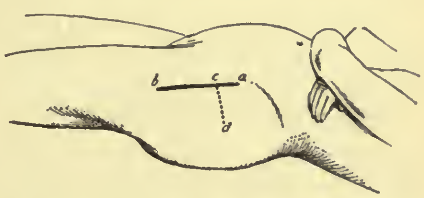


FIG. 140.—INCISION FOR THE OPERATIVE TREATMENT OF CONGENITAL DISLOCATION OF THE HIP. The line *ab* runs in the interval between the sartorius and the tensor vaginæ femoris muscles, from which there is easy access to the hip-joint. The dotted line *cd* shows the second incision, if more room be required.

Before closing the wound an attempt should be made to narrow the dilated front part of the capsule of the hip-joint sufficiently to allow it to exert some influence in preventing recurrence of the dislocation. We usually excise a large elliptical piece from it and bring the edges together with stout catgut. The deeper structures are then brought together with catgut, and the wound is closed without drainage. The limb is put up in a plaster of Paris spica in the position mentioned above, and it should be kept in this for about ten days, at the end of which time the stitches are taken out, and a second plaster casing is applied. If a Gigli's wire saw be used, there is no difficulty in removing the plaster casing without risk of disturbing the position of the joint surfaces. The case is now treated on lines exactly similar to those for the bloodless method (see p. 398).

Results.—The results of this operation are often very satisfactory, and we have had a number of cases in which the head of the bone has apparently remained in the acetabulum, which has developed normally. In others the head has slipped out of place within a few days or weeks of the operation subsequently, and in some of these we have successfully re-opened the wound and replaced the head. Sometimes, however, failure results either from inability to get the head of the bone in place at the operation owing to long-standing and general shortening of the tissues or from inability to keep the head in place afterwards. In these cases the head lodges beneath the anterior superior iliac spine, and a good firm new joint may result.

We have now had the opportunity of watching many cases treated both by the operative and non-operative methods for many years after the dislocation has been reduced, in some instances for twelve years or more. On the whole we must confess that the later results have disappointed us. The tendency to recurrence of the displacement never seems to be overcome entirely, and we have had a case of spontaneous recurrence of the displacement ten years after apparently perfect re-position by the open method. During all this time the child showed no sign of limping, and lived her usual life, and a series of radiograms taken annually showed the head of the bone apparently in perfect position in a normally placed and developed acetabulum. It may be that the loss of the ligamentum teres has something to do with this. In no case have we had any anchylosis, nor indeed any troublesome stiffness of the joint after the casings are removed, and this we attribute partly to avoidance of sepsis, but chiefly to abstinence from interference with the shape of the articular surfaces. In the older open operation of Hoffa the joint surfaces were remodelled, and anchylosis was a frequent result.

Summary of Treatment.—All cases seen in infancy should be treated by manipulations (see p. 395) until the child is two or three years old, and then Lorenz's bloodless method (see p. 395) should be tried. Should this fail after a second attempt, or should the child be seven or eight years of age when treatment is begun, the open operation should be resorted to. No case under the age of eight years should be abandoned as incurable until open operation has been tried, and no case should be called a cure unless a stereoscopic radiogram shows that the head of the bone lies in the acetabulum. Provided that the surgeon be sure of his asepsis there is no risk attaching to the operation, which is not unduly prolonged nor accompanied by severe bleeding. The really difficult point is to keep the limb in its proper position during the suturing of the wound, etc.

OTHER CONGENITAL DISLOCATIONS.

Congenital dislocation is sometimes seen in the shoulder joint, the head of the humerus being usually displaced backwards on to the scapula ; occasionally a downward or forward displacement may be present.

In the elbow joint, the head of the radius is not very uncommonly displaced forwards on to the lower end of the humerus. If the movements of the fore-arm be interfered with, the head of the bone may be excised, but as a rule no treatment is necessary. Sometimes both ulna and radius are displaced backwards.

Displacements of the knee-joint or of the patella in a lateral direction, also occur as a congenital deformity. They do not need any special description.

CHAPTER XXI.

KYPHOSIS: SCOLIOSIS.

UNDER this heading are included the forms of spinal curvature which are not due to disease of the vertebræ, in contradistinction to the disease known as angular curvature or Pott's disease, which is due to a tuberculous affection.

Two forms of functional curvature of the spine are met with in practice. The first is known as kyphosis, or general curvature of the spine; and although in time it may lead to the second and more serious form known as scoliosis, it is, as a rule, transient in nature and easy to treat.

KYPHOSIS.

In Infancy.—This is usually associated with considerable muscular weakness, and also with rickets. As a rule it is temporary, and disappears as the child grows stronger. In bad cases, however, especially in those with extensive rickets, the curvature persists, and the child grows up round-backed and stooping. The condition, if persistent, is very likely to become the starting-point of scoliosis, and therefore always requires treatment.

A child who is the subject of kyphosis has a constant tendency to sprawl upon the back, and is unable voluntarily to assume the sitting posture. When the child is sat up, the trunk is bunched forward and the spine is strongly bowed backwards, so that the chin often nearly touches the knees and the spine is bent forwards into one large C-like curve. There is no want of mobility of the spine, and usually no tenderness on pressure. The curvature disappears entirely when the child is laid flat on the back upon a hard level surface, except in advanced cases of long standing. There is no lateral curvature unless the kyphosis has persisted for a considerable time.

In Adult Life.—Kyphosis in the adult is generally due to the habitual adoption of an exaggerated faulty position, such for instance as that assumed by some bicyclists. At a more advanced age the condition may result from senile degeneration ; the spinal muscles lose their tone, and the vertebral column becomes bowed forward in consequence. This of course is part of general debility, and calls for no special treatment. Kyphosis may complicate general diseases such as osteo-arthritis and osteo-malacia. It is also common in osteitis deformans, and is met with in some forms of paralysis, in which it is due to atrophy of the erectors of the spine.

TREATMENT.—*In infants* it is of the first importance that the child should always be carried in the horizontal position, and never be sat up in the nurse's arms. The upright position favours the bending forward of the head, which, in a weakly subject, leads to bowing of the spine and this condition of kyphosis. With an intelligent nurse it is easy to have this order properly carried out, and no apparatus is necessary. In the case of hospital patients, however, it is well to insist that the child shall be carried about on some form of tray, upon which it lies always in a horizontal position. Wickerwork trays, appropriately padded, can be bought, and are very suitable and inexpensive. A basket-lid or an ironing-board padded with a folded blanket answers the purpose quite well.

When the child approaches the end of its first year, and begins to sit up and crawl about, it is not so easy to keep him in the horizontal position as when he is quite young ; for these children the horizontal position must be insisted upon as much as possible, but in addition it is well to apply some light spinal support which will prevent bending of the vertebral column. We are in the habit of moulding a sheet of guttapercha, leather, or poroplastic felt over the sides and back of the thorax, and fixing it above and below by bands of webbing passing across the front of the shoulders and the upper parts of the thighs, steadying the whole by a firm bandage. This provides a light but stiff support which counteracts any tendency of the spine to assume the bent position, and the child may be allowed to sit up and crawl about with comparative freedom wearing this apparatus.

The general health must receive careful attention. If rickets be present, the measures appropriate for that affection (see Vol. II.) must be adopted. Cod liver oil and iron are of benefit, as is massage of the back muscles night and morning for ten minutes at a time.

The kyphosis of adult life resulting from faulty positions must be treated by attention to posture and, if necessary, giving up the particular occupation that has brought about the curvature. In addition, it is well to order massage and gymnastic exercises designed to extend the spine and strengthen the erector muscles. These are described on p. 423.

The treatment of the kyphosis occurring in the course of diseases such as osteo-arthritis, osteo-malacia, and osteitis deformans must be that of the primary disease of which the spinal deformity is a mere episode, which does not, as a rule, gives rise to any discomfort.

SCOLIOSIS.

By scoliosis is understood a lateral deviation of the spine, accompanied by rotation of the vertebræ upon their vertical axes; this latter occurrence is essential for the production of true scoliosis, for it is possible to have a lateral deviation of the spine without rotation of the vertebræ —when the case is strictly one of lateral curvature rather than of true scoliosis. The two terms should be kept distinct, but at the same time it must be remembered that many cases of true scoliosis commence as simple lateral deviation of the spinal column, and the rotation of the vertebræ only takes place at a later period; this is particularly the case when the spinal muscles are weak. Simple lateral curvature, if treated sufficiently early, does not necessarily give rise to true scoliosis.

CAUSES.—We shall not attempt to go at length into the mechanics of this condition, but various experiments seem to prove that the most essential factor in the production of scoliosis is the transmission of the weight of the upper part of the body through a vertebral column, which, by the enfeeblement of its various muscles, or by the habitual maintenance of a faulty position, has undergone lateral deviation. The constant pressure acting upon a spinal column so deflected will inevitably produce rotation of the vertebræ on account of the conformation of the constituent parts of the curved spine and their articulations.

The condition is predisposed to by any cause of general debility, particularly rickets and anæmia, and is greatly favoured by over-fatigue and the constant assumption of faulty attitudes. The latter, by causing a deviation of the spinal column, place the spinal muscles on one side at a mechanical disadvantage compared with their fellows on the opposite side, and, if a faulty position be assumed habitually, the muscles that are at a mechanical advantage will keep up or even accentuate the curvature, and will eventually produce the rotation of the vertebræ already spoken of. This rotation always takes place in one direction; the bodies of the vertebræ are rotated outwards towards the convexity of the curve, whilst the spinous and other processes are rotated inwards towards the concavity—*i.e.* towards the middle line of the body.

It will perhaps help to make the matter clear from the point of view of treatment if we classify cases of lateral curvature, according to their causes into four main groups:

Cases due to inequality in length of the supports of the spine.—This group is of the highest importance, and embraces many causes which are constantly met with in practice. Unless the base of the support of the spine (*i.e.* the sacrum) be horizontal, a certain amount of curvature must necessarily result. However slight the obliquity may be, it is sufficient to prove the starting-point of a severe scoliosis in susceptible subjects. In strong healthy persons, on the other hand, this obliquity may be corrected easily and pass practically unnoticed. A very common cause is obliquity of the pelvis, resulting from an inequality in length of the two lower limbs. This may occur from various causes, such as tuberculous hip disease, congenital dislocation of the hip, the arrest of development which follows infantile paralysis, simple asymmetry, etc. In weakly subjects scoliosis is a common complication of bad genu valgum or even of flat foot. The primary curve in this group is usually in the lumbar or lower dorsal region.

Cases due to inequality in the weight borne on the two sides of the spine.—Common examples of this are seen in nursemaids who habitually carry children upon one arm, labourers carrying hods, pails, or heavy weights always on the same side, or cases in which amputation at one shoulder joint has been performed in a young subject. Scoliosis does not necessarily occur in every case in which unequal weights are carried on the two sides; as long as the subject is strong and vigorous, and the weight carried is not out of proportion to the strength of the muscles, the latter are able to maintain their tone and to keep the spine erect when the position of rest is assumed. When, however, the muscular system is weak or the weight is excessive, and particularly when it is carried for long periods at a time, scoliosis is apt to result.

Cases primarily due to weakness of the spinal muscles, aided by the habitual assumption of a faulty position.—This cause is responsible for a large number of cases. As long as the patient is in good health, the muscles upon the two sides of the spine act together to keep that structure erect; but in certain subjects, and especially at certain periods of life, muscular weakness occurs, and the muscles are no longer equal to their task of keeping the spine in its normal position for any length of time. This is most frequently seen in girls between the ages of twelve and seventeen—a period which comprises the onset of menstruation, and the abandonment of the free vigorous life and exercises of childhood. It is a period often marked by a predilection for sedentary habits, the semi-recumbent position, confinement to heated rooms and the keeping of late hours, together with the assumption of tight-fitting garments which hinder the free play of the muscles so essential to the proper development of the trunk. The condition is still further aggravated if anæmia be present; fatigue is then produced by any slight muscular exertion, and this also leads to avoidance of active exercise and the assumption of faulty attitudes.

One of the most potent factors in the production of scoliosis is over-fatigue, due to prolonged standing, sitting, or walking. Nursemaids, type-writers, school children continuously engaged in reading, writing, or piano-playing, occupations which involve the habitual assumption of a faulty position of the spine, may all develop scoliosis, should the general health be such as to cause enfeeblement of the muscles. A similar result occurs in girls who are in the habit of riding on horseback for periods long enough to cause fatigue to the muscles of the back, and to lead to a faulty position of the spine. It is on this account that rapidly growing weakly girls are recommended to ride on opposite sides of the horse on alternate days, so as to exercise equally the erector muscles on the two sides. Scoliosis may also be produced in children if they are always carried on the same arm, whereas if they are carried first upon one arm and then upon the other, no harm results either to the nurse or the child.

Cases in which the deformity is secondary to other affections of the spine or thorax.—Here the curvature of the spine is mechanical, and is produced by some alteration in that structure itself, or in the capacity of the thorax. Familiar examples are lateral curvature secondary to empyema, collapse of the lung, rickets, and tuberculous disease of the spine, etc.

PATHOLOGICAL CHANGES.—After a time organic changes take place in the ligaments and the bones, so that a curvature, which at first could be easily rectified by appropriate position, becomes more and more permanent. The first change that occurs is an alteration in length of the various fibrous structures on the two sides, those upon the convexity becoming stretched, and those upon the opposite side being proportionately shortened. In advanced cases, the vertebral bodies themselves become altered so that each is somewhat wedge-shaped, the base of the wedge being directed towards the convexity of the curve. The surfaces of the various articular processes also become altered in direction. These bony changes are permanent, and account for the intractability of the severe cases.

SYMPTOMS.—The symptoms of scoliosis may be divided into the objective and subjective symptoms.

Objective Symptoms.—Sometimes the spine is bent to one side in a large single C-shaped curve, which may either involve the entire vertebral column, or may be confined to the lumbar or dorsal regions. Should a curvature of this kind be at all marked, it will be necessary for one or more compensatory curves to be formed in the opposite direction for the adjustment of the centre of gravity of the body, as otherwise the erect position could not be maintained. These compensatory curves have their curvature in the opposite direction to the main one, and are smaller in extent than the primary curve.

In the common form of scoliosis there are generally two curves which have their convexities in opposite directions, so that the spine somewhat resembles the letter S. Of these, one is usually called the primary and the other the secondary curve. The primary curve cannot always be clearly distinguished, but a fair idea can generally be gained by considering the mechanism of the formation of the curvature. If due to an inequality in length of the lower extremities, the primary curve will be in the lumbar or lower dorsal region, whilst that in the upper dorsal is merely compensatory; on the other hand, if the curvature be due to faulty position, the primary curve is usually in the upper dorsal region, whilst the compensatory curve is below it. When the primary curve is very marked there may be three or even more curves in the spine ; the primary curve is then generally very acute, and at either end of it there is a compensatory curve. This is usually the case in severe dorsal curvature, when there is a compensatory curve in the cervical and another in the lumbar region. In some cases certain spinous processes may project markedly backwards ; the case then requires careful examination in order to distinguish it from tuberculous disease.

A marked objective symptom is asymmetry of the thorax. The shoulder upon the side of the convexity of the curve is higher than its fellow ; the intercostal spaces are considerably wider on that side, whilst they are narrowed upon the side of the concavity. The spinous processes deviate from the middle line. The distance between the lower ribs and the crest of the ilium on one side is much increased, whilst there is a deep fold in the corresponding situation on the opposite side. The total body height is diminished.

When there is much rotation of the bodies of the vertebræ, the thorax undergoes extensive deformity ; the ribs on the side of the convexity of the curve are carried backwards, whilst they travel in a forward direction on the opposite side. The shape of the two sides of the thorax is therefore greatly altered. On the side of the convexity the vertical measurement of the thoracic cavity is increased, owing to the separation of the ribs, but the transverse one is lessened. On the side of the concavity the reverse is the case, but probably the cubic capacity on the two sides is but slightly altered. The angles of the ribs on the side of the convexity become more acute, whilst those on the opposite side either remain unaltered or become more obtuse. The result is a prominent ridge upon the side of the convexity formed by the angles of the ribs with the erector muscles over them. The clavicle on that side may have its curves increased, and cases are recorded in which the sternal end has become dislocated. The scapula on the side of the convexity is carried backwards to a plane posterior to its fellow, and is raised and sometimes tilted. The arm on the opposite side hangs away from the thorax.

Subjective Symptoms.—The subjective symptoms are usually slight, but may become exaggerated in neurotic subjects or in those in whom the deformity is extreme. There is aching pain, and a feeling of weariness in the back and loins, sometimes extending down to the thighs. When the deformity has lasted long and extensive bony changes have occurred, there may be considerable pain, partly from the pull upon the stretched ligaments and partly from direct pressure upon the nerves or the viscera. The lung may be compressed upon the side of the convexity, and patients with long-standing dorsal curvature are apt to suffer from severe bronchitis ; the heart may also be displaced, and the liver and spleen unduly pressed upon.

There should be no difficulty in diagnosing this condition from tuberculous disease, as in scoliosis there is no rigidity and no tenderness on pressure over the affected vertebræ or on jarring down through the head. Moreover, except in rare cases, there is no projection backwards of the vertebræ.

EXAMINATION.—In examining a subject of scoliosis in order to determine the treatment to be adopted, a certain routine should be gone through.

The patient should be stripped to the hips and should stand in a position of ease with her back to the surgeon, the garments being fastened with a safety-pin to prevent them slipping down and to avoid the constant changes of position that accompany the endeavours to hold them up. The spinous processes should then be marked upon the skin with a carbon pencil and a sheet of paper pressed over them so as to obtain a permanent record; the marks made by the pencil will be transferred to the paper, which can be varnished and kept for reference. A slight deviation of the spine is best detected by letting fall a plumb-line from the spinous process of the seventh cervical vertebra. Any deviation of the spinous processes from the vertical can be measured.

The next important point is to ascertain whether there is any obliquity of the pelvis. The patient is turned round, and the surgeon, standing or kneeling in front, places a thumb upon each anterior superior iliac spine and notes whether they are on the same horizontal level; in case of doubt, the patient should stand quite erect, with the feet together, and the length of the lower extremities should then be measured from the anterior superior spine to the floor on each side. The presence of flat foot or knock knee should also be looked for.

The next point is to determine what amount of alteration can be made in the curvature by alteration in position; in other words, the flexibility of the spinal column is tested. The patient should be directed to hold herself as erect as possible, and any alteration in the curvature is then compared with the measurements taken in the position of rest. In slight curvatures marked improvement is produced by the effort of standing to attention. Should the curvature be due to inequality in the length of the lower extremities, suitable blocks must be placed beneath the shortened limb so as to make the pelvis horizontal, and the effect upon the curvature noted. In early cases this will obliterate it entirely.

The patient should next be suspended by the hands from a bar, with the feet just off the ground, so that the entire weight of the body is borne by the arms. A more accurate method is to use a trapeze with two bars, the upper one being three inches above the lower, hung just high enough to swing the patient free of the ground. The lower bar is grasped with the hand upon the side of the convexity, whilst the upper is laid hold of with the other; this pulls upon the spinal column and tends to straighten

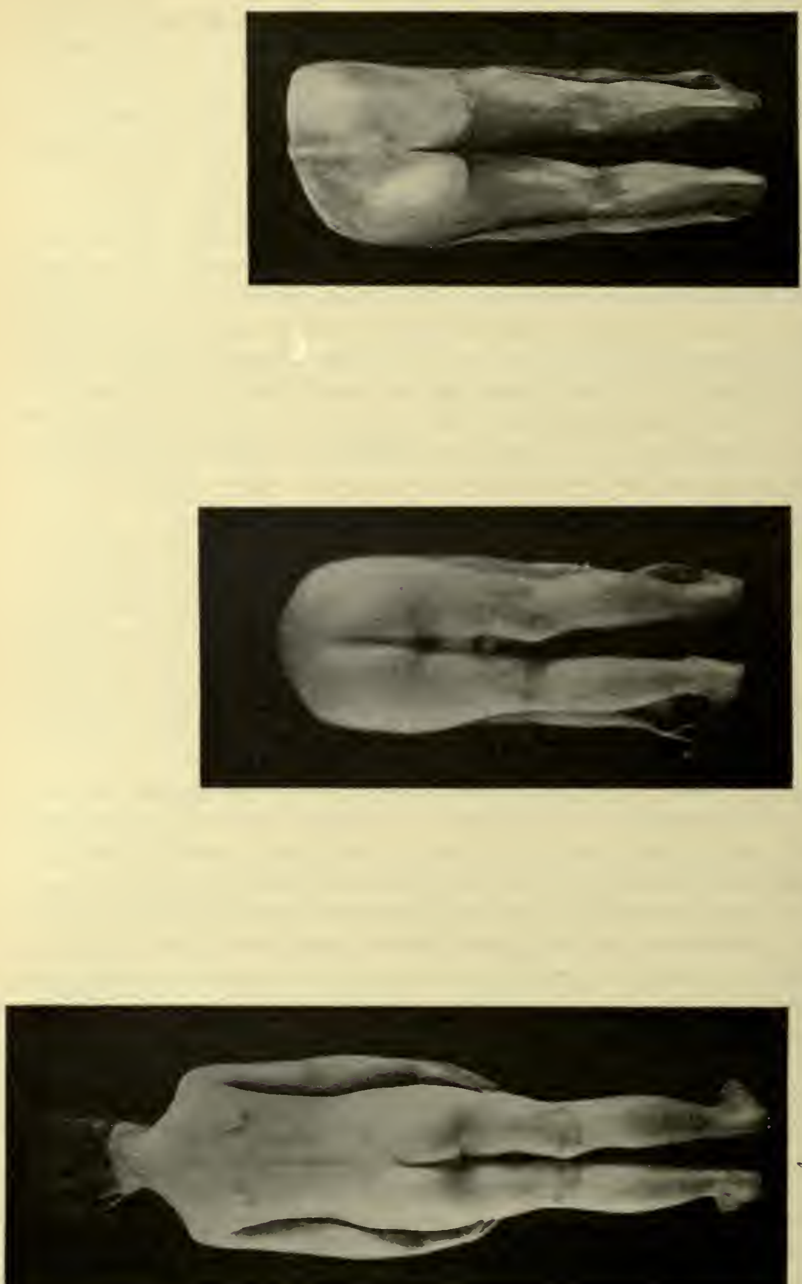


FIG. 141.—THE EXAMINATION OF A SUSPECTED CASE OF SCOLIOSIS.—*A* is the photograph of a child showing elevation of the right shoulder due to faulty posture. The absence of rotation is demonstrated in *B* by making the child touch his toes, when the outline of the back is seen to be quite symmetrical. In *C* there is true scoliosis, and the outline of the back is asymmetrical, the curve of the ribs being increased on the side of the convexity.

the curve. The positions of the spinous processes are now noted and compared with those observed in the standing-at-ease position. In young children the bar may be dispensed with, the child being lifted from the ground by the arms.

The patient should next be made to stand erect and bend forward slowly until the fingers touch the toes. The amount of rotation can then be estimated by noticing the asymmetry of the ribs. If it be desired to record this, a tracing of the contour of the posterior aspect of the ribs can be made with a pleximeter. This will enable the surgeon to differentiate between a case of lateral curvature and one of true scoliosis. In the patient shown in Fig. 141 *A* there was a marked difference in the level of the shoulders; on making the child stoop down, however, the two sides of the thorax are quite symmetrical, showing that no rotation of the vertebræ was present. In Fig. 141 *C* is shown the condition found in a case of true scoliosis with considerable rotation of the vertebræ. Cases are also seen in which there is very little curvature present, but on making the patient stoop advanced rotation is at once evident; deformity of this kind is a symptom of bad import, as it is more difficult to rectify than the ordinary lateral curvature.

PROGNOSIS.—The method of examination just described is of great importance both in prognosis and in treatment, as it shows how much flexibility remains in the spine and gives a good indication of the best result that can be expected from treatment. When suspension fails to obliterate the curve entirely, we may fairly conclude that ligamentous or even bony changes have taken place in the spinal column, and that therefore perfect restoration of the erect position is not likely to result from treatment. On the other hand, a hopeful prognosis may be given in those cases in which the spine straightens out completely, and the chances are that, with proper care and suitable treatment, the curve may be entirely obliterated.

When called upon to give a definite prognosis in these cases, the surgeon must remember that a large number of the minor degrees are of a purely temporary nature, depending probably upon some defect in the general health, and that the curvature will either be arrested or cured as the muscles recover their tone. The disparity between the number of cases of slight lateral curvature coming under notice in early life and those adult cases in which the curvature amounts to actual deformity proves that something of this kind probably occurs in the majority of cases. The cases most prone to undergo spontaneous cure are those in which there are two slight equal curves rather than a single large C-shaped one, which tends to increase and to result in important rotation changes since there is no compensation.

When the curvature is due to inequality in length of the two extremities the cases are very amenable to treatment if seen within a reasonable time, and a good result can generally be obtained. The opposite is the case when the curvature is the sequela of some chest disease, such as empyema.

Perhaps, however, the most important feature in the prognosis is the condition of the patient's health. Scoliosis associated with profound anæmia is most difficult to treat, and little beneficial effect upon the curvature is to be looked for unless the anæmia can be treated with success. The most difficult cases of all are in anæmic girls about the age of puberty who also suffer from dysmenorrhœa; when these conditions are combined with a neurotic taint, the case may prove intractable.

The age of the patient at the onset of the curvature is of great importance. In a very young child the vertebræ are soft and easily moulded, and there is a long period during which the spine may undergo serious structural alterations unless it be maintained in proper position. When the disease begins only a short time before ossification is complete, however, there is little time for great changes to take place in the vertebræ. The curvature will therefore develop much more slowly—an important point with regard to treatment.

TREATMENT.—The question of prophylaxis must always be borne in mind by those who have charge of patients who are likely to become the subjects of this affection.

Prophylaxis.—*When there is obliquity of the pelvis.*—Any patient with inequality in the length of the lower extremities should receive treatment directed to remedying the resulting obliquity of the pelvis. When a patient has been the subject of hip disease and is left with deformity and shortening of the limb, the deformity must be remedied as far as possible, and a high boot must be worn on the affected limb so as to make the two limbs the same length. Congenital dislocation of the hip should receive appropriate treatment (see p. 394). Apparatus will be required for cases of arrest of development following infantile paralysis, whilst genu valgum and flat foot should be treated upon the lines laid down in Chapters XVIII. and XV.

When heavy weights are carried upon one side.—The obvious prophylactic remedy here is to see that any weight likely to produce curvature is carried alternately upon the two sides. Nursemaids should be told to carry children alternately upon either arm—an order that will benefit both child and nurse alike. When an arm has been lost, the patient should be forbidden to carry heavy weights; if enough of the limb remains to allow an artificial limb to be fitted, the weight should be carried alternately by the natural and the artificial limb.

When there is weakness of the spinal muscles.—The ordinary rules for personal hygiene must be insisted upon, but there are certain special points to which attention should be paid. Weakly children or those suffering from rickets should be carried in the horizontal position in the nurse's arms; they should never be carried upright even when they have become strong and healthy unless they can be carried alternately on either arm. Massage of the back muscles, with applications of sea-water douches is of value. The massage should be done for about a quarter of an hour at a time night and morning, and should be followed by a sea-water douche.

Special care is needed in the case of rapidly growing girls who are nearing the period of puberty. All heavy or constricting garments about the chest or abdomen which interfere with the free play of the thoracic, abdominal, and spinal muscles should be forbidden, and the child should be encouraged to play games, to lead a healthy outdoor life, and to go through a mild gymnastic course. Sedentary habits, the desire to remain in the house in the recumbent position reading novels should be checked, and in fact the life of the two sexes should be assimilated as much as possible. Girls who ride on horseback, and in whom there is any tendency to curvature, should ride astride or upon a reversible saddle so that the exercise can be taken on alternate sides; the rides should never be long enough to produce fatigue. Corsets of any kind are bad, and if employed should not be allowed to compress the chest.

This is about the period of life at which curvature is apt to occur as a result of faulty position. Some attention has been directed to the possibility of producing lateral curvature by faulty positions during sleep. Many children sleep upon the back, and this is obviously the best position. A large number, however, lie upon one side, and it has been said that, if a child is in the habit of lying more upon one side than the other, this may produce curvature of the spine. This is probably an exaggerated view, but it is well to encourage sleeping upon alternate sides if the child be unable to sleep upon the back. The mattress should be firm and a feather-bed should be avoided; the head should not be raised unduly.

The positions usually adopted by children at school when sitting at a desk, writing, reading, or drawing, or when playing the piano, are often faulty, and calculated to produce scoliosis. The child is generally either seated upon a form without any back, or upon a chair, the back of which is too straight and not high enough, whilst the seat is too far from the ground, and there is a want of proportion between the height of the desk and the chair or form upon which the child sits. The result is that the child soon gets tired, brings the pelvis to the edge of the chair in order to enable the feet to touch the ground and support him, and he is often obliged to tilt the pelvis in order to bring one foot into contact with the floor. The spine is thus unsupported, and the child either stoops forward or bends to one side so as to rest his elbow upon the desk at which he is writing.

The want of proper proportion between the height of the seat and the desk plays a very important part, for, when the desk is too high, the right arm has to be unduly elevated if the child wishes to write, whilst if the desk be too low it has to be unduly depressed and the left shoulder is consequently raised. This may lead to the development of a marked lateral curvature in a weakly child.

The chief requisites for a school seat and desk will be seen on reference to Fig. 142. The back of the chair should extend upwards as high as the shoulders, and should be prolonged high enough to support the head if the child suffers from a weak spine. The seat should be at such a height from the ground that the feet rest easily upon the floor, or upon a foot-rest inclined at an angle of about 20°. The breadth of the chair-seat should be equal to the length of the child's thighs, and there should be just room between the seat of the chair and the under surface of the desk for the thighs. The precise measurements usually given are that the lower edge of the desk should be an eighth of the height of a girl and a one-seventh that of a boy above the seat of the chair. The writing desk should have a gentle slope so as not to force the child to bend forward too much when he wishes to read or write.

FIG. 142.—A WELL-DESIGNED DESK AND SEAT. Both desk and seat can be raised or lowered about 4 inches.

Any defect of vision should be attended to, and the child fitted with suitable glasses so as to avoid all necessity of stooping over the desk, which is likely to act injuriously in producing curvature. *Exercises* to develop and strengthen the chest muscles should be prescribed unless the child be obviously perfectly robust. *Massage* will also be called for when there is any actual weakness of the spine; this important factor in treatment should never be omitted. The exercises are dealt with on p. 423.

When there has been disease within the thorax, etc.—In some of these cases little can be done in the way of prophylaxis. In cases of Pott's disease and rickets, appropriate treatment for the disease will stave off the onset of scoliosis. After empyema or collapse of the lung, some curvature is inevitable; it may, however, be minimised by prescribing exercises directed to bending the spine in a direction opposite to that in which the curvature is expected to take place; these exercises should be begun before any curvature has been detected and should be persevered with for many years.

When Scoliosis has developed.—These cases may be divided into four large groups: (*a*) the curvatures of infancy, (*b*) those occurring during childhood, (*c*) those occurring during the period of adolescence, and (*d*) those occurring after growth is complete.

The Scoliosis of Infancy.—The remarks made with reference to the treatment of kyphosis (see p. 404) will apply largely to this condition. The general health requires attention; rickets must be treated by proper feeding, hygienic measures, and the regular administration of appropriate drugs (see Vol. II.). The child should be kept in the horizontal position, either in the nurse's arms or upon a suitably padded tray or basket. After the first year, the back support recommended for kyphosis (see p. 404) may be employed, but recumbency must still be insisted upon, so as to relieve the back from the superincumbent weight. The child should always be sent to the country or the seaside for a considerable period if possible, and massage to the back muscles should be employed night and morning.

Walking should be discouraged; mothers are anxious for the child to begin to walk early, but the importance of the recumbent position should be pointed out, and attempts at walking prohibited. The child should be encouraged to sleep upon the back, and may if necessary be fastened down upon a suitably padded wicker tray in that position. Special bed splints are sold for this purpose and may be used if preferred. Should there be a marked curvature, however, the lateral position may be substituted for the dorsal, the child being taught to lie upon the side of the convexity of the curve in the dorsal region, with a firm pillow or small bolster interposed between the mattress and the thorax, with the object of unfolding the curve. The mattress should be firm; a feather bed should be avoided, and the child should sleep with the head supported by one small pillow.

The Scoliosis of Childhood.—Great care has to be exercised in the treatment of curvatures during this period of life, for, although on the one hand the spine is extremely flexible, and therefore can be easily influenced by treatment, this fact may be a source of actual danger, because the curve if neglected will lead to such marked distortion of the bones when they become fully ossified as to render treatment very difficult.

Removal of the Cause.—Before proceeding to attack the curvature itself, any cause that may originate or keep up the vicious position should be eliminated. Any obliquity of the pelvis, due to inequality in the length of the lower extremities, must be remedied by suitable means, such as boots or operation. Any vicious attitude acquired while sitting or standing at lessons, or even in playing games, must be carefully inquired for and forbidden, while some other attitude or game which tends to rectify the faulty position thus produced should be substituted. Any optical defects, such as myopia, should receive treatment; adenoids or enlarged tonsils should be removed.

Medicinal Treatment.—In addition to this, the general health must receive attention, as it is extremely common to find some physical ailment in this group of cases. Of these the principal is anæmia; dyspepsia or constipation should receive suitable treatment. The diet should be abundant, light, and digestible; cod liver oil should be given when the child is particularly weakly. The patient should be in the fresh air as much as possible in the country or at the seaside, and the size and ventilation of the living and sleeping rooms should receive due attention.

The most important point, however, is the avoidance of fatigue, which rapidly enfeebles the muscles. The treatment of the curvature itself will require a nice discrimination between rest and exercises, the latter being designed to strengthen the muscles, the former to avoid tiring them. Children at this period of life should lead a healthy, active, outdoor life. Sitting and standing at lessons must be discouraged in favour of outdoor exercise, which, by improving the general health and the muscular tone, helps to cure the curvature. The child may remain at school provided that she sits upon a proper seat before a well-constructed desk (see p. 414) and has proper rest combined with suitable gymnastic exercises (*vide infra*); the advantage of allowing her to remain at school is that she will probably be more amenable to the discipline required for the proper performance of the exercises.

Recumbency.—Rest in the recumbent position must always be insisted upon. The period of rest must be regulated by the particular features of the case, but in nearly all cases at least two hours a day are required. It is well to divide this period up into two equal portions and to order the patient to rest upon a couch for an hour about midday and for another hour in the late afternoon. If the patient will tolerate it, the prone position is better than the supine; many children, however, strongly object to this, and there is no real objection to employing the other. As a compromise, the child may be placed first in the prone position until it becomes too irksome, when the supine position may be assumed. The rest may be taken upon an ordinary hard couch; it is better, however, to have a spinal couch so that the patient lies upon a slightly inclined plane.

Exercises.—Mechanical exercises should always be advised with the view of strengthening the muscles generally and of restoring the tone of those to whose failure the curvature is due. *When the curvature is only slight,* little is required beyond general muscular exercises which can be carried out at home under the supervision of the parents or a capable nurse. Good types of these will be found on p. 423 (see Series A, B, C, E, F, G, I). They should be practised daily for ten minutes to half an hour at a time in the late forenoon; immediately after them the child should lie down for the midday rest. Dumb-bell exercises may also be performed on rising in the morning for five to fifteen minutes before dressing.

The dumb-bells should not exceed a pound in weight at the outset; as the patient becomes more used to the exercises, the weight may be increased, as may also the length of time during which the exercises are performed. The home exercises recommended above may be done with dumb-bells, and are then equivalent to exercises carried out against resistance.

Riding exercise is useful, so long as it is not allowed to cause fatigue. A girl should ride upon the same side of the horse as that upon which the convexity of the curve is, so that there will be a tendency to open out the curvature. In the early stages of the treatment it is important to impress upon the parents that, when any of these forms of exercise cause fatigue, they should be stopped at once and the child allowed to rest.

Massage.—Massage to the muscles of the back should never be omitted. It should be employed twice a day for about half an hour, after breakfast and before going to bed.

When the curvature is very marked, it will be necessary to employ special exercises and other procedures designed to act directly upon the curvature, in addition to those which aim at improving the muscles generally. The case will then be closely allied to those about to be described in the following paragraphs, and the exercises will be the same.

The Curvatures of Adolescence.—The treatment of the curvatures which occur between puberty and the final cessation of growth often presents considerable difficulty owing to the impossibility of insisting upon the healthy outdoor life which it is comparatively easy to secure for younger patients.

The general indications for treatment are similar to those for the preceding group. Any mechanical cause must be removed, and the general health attended to; menstrual irregularities, anæmia, or constipation must be treated; careful personal hygiene should be insisted upon, and the patient compelled to take regular exercise, to avoid late hours and hot, ill-ventilated rooms, and to take simple, regular, and easily digested meals. Fatigue and faulty positions should be avoided, and any desks, chairs, or music-stools that the patient uses must be made to suit the individual requirements of the case. A cold sponge bath in summer and a tepid one in winter should be taken on rising in the morning, and the back muscles should be massaged and developed by the exercises which will presently be described. The following breathing exercises are also good:

1. The patient stands erect with the arms stretched out at right angles to the body and the palms downwards.

2. The arms are rotated outwards so as to bring the palms upwards and put the pectoral muscles on the stretch.

3. The arms are now brought vertically above the head, the patient inspiring meanwhile through the nose; the breath is held while the patient counts five and then is allowed to escape as the arms fall to the side of the body.

The treatment of the curvature will vary according to the flexibility of the spine—that is to say, according to the straightening produced when the patient is suspended. We may divide these cases into (α) those in which the curve can be obliterated, (β) those in which the curve can be ameliorated but not entirely obliterated, and (γ) those in which no alteration can be produced.

(α) **The cases in which the curve can be obliterated.**—Here the prognosis is good, as the muscular apparatus is probably alone at fault, and no bony or ligamentous changes have yet occurred in the spine. The object of the treatment, therefore, is to strengthen the back muscles, and thus enable them to perform their function of keeping the spine erect. One of the most important ways of doing this is by suitable exercises.

Exercises.—A multitude of different exercises have been designed for the treatment of these cases, many of which are extremely complicated. There are, however, no specific exercises for the cure of this condition, and the surgeon can easily design efficient ones for himself by observing accurately the changes that have occurred and the muscles that are at fault, and ordering movements which will bring into play the defective muscles, and mechanically rectify the physical changes in the trunk. These exercises should always be carried out in the presence of some one whose business it is to see that they are properly and regularly performed for the requisite length of time. The simplest plan is for the surgeon to supervise the first performance of each group of exercises as they are taught, and to point out to the gymnasium master or to the parents the exact manner in which they are to be done. It is well to teach a fresh set of exercises at each sitting, or each alternate one, so as to stimulate the patient's interest as much as possible; and when the whole series has been learnt, the performance should be varied judiciously. The exercises should be so planned that they are carried out first in the horizontal, then in the sitting, and finally in the standing position, as the muscular strength improves. An important point is that many of the exercises are performed against resistance, the surgeon, or some form of elastic apparatus, opposing the action of the muscles. After the exercises are over, the patient should recline upon a couch, in the prone position, for at

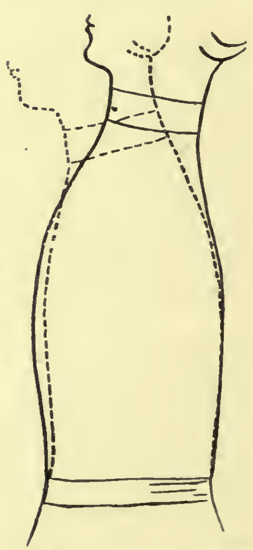


FIG. 143.—SKETCH SHOWING THE INFLUENCE OF EXERCISES UPON POSTURE AND CHEST CAPACITY. The sketch is from an actual pleximeter tracing. The dotted line shows the outline before, the continuous one that after the treatment.

least half an hour. The period for which the exercises are performed may be gradually increased, if they are doing good and no undue fatigue is produced.

At the end of a month or six weeks from the commencement of the treatment, after the simple exercises designed to improve the muscular system generally have been thoroughly learnt and properly practised, the surgeon should ascertain what effect has been produced upon the curvature. Should it be found, as it probably will be in early cases, that the curvature has almost disappeared, and that the patient can hold herself erect without any trouble, little else is needed beyond continuance of the treatment already adopted. Should the curvature still persist, special exercises and 'postures' (see Figs. 144–5) designed to open out the curve will be required.

The object of postural treatment is to restore the spine to its normal condition or even to over-correct the deformity slightly. The posture employed must be adapted to the individual case, only those being chosen which correct the deformity most completely. For example, the following postures will be found useful for a patient suffering from a dorsal curvature which is convex to the right and has compensatory cervical and lumbar curves which are convex to the left. The head is carried well back and held erect. The patient then puts the left hand at the back of the neck, with the fingers over the spine and the thumb resting about the middle of the sterno-mastoid, and thrusts the elbow forwards and to the left so as to draw the scapula away from the middle line. This exerts traction on the rhomboids and tends to pull the spines of the dorsal vertebræ to the left. The patient's right hand is now placed upon the right side of the thorax, the fingers behind and the thumb forward, and makes firm pressure over the convexity of the dorsal curve, while the left arm and elbow are kept well forward. The body is now held rigidly in the improved position that this posture produces while an attempt is made to correct the lumbar curve by separating the right leg from the left by a short step outwards so as to depress the right side of the pelvis. The rotation of the bodies of the lumbar vertebræ may now be corrected by taking a short step forward with the left foot so as to twist the lumbo-sacral joint to the right.

While the patient maintains this position, flexion and extension of the spine should be carried out, the head being alternately flexed with the rest of the trunk and kept extended by fixing the eyes on a distant object. Another excellent posture is that in which the patient stands erect with the hands upon the iliac crests and makes forcible pressure downwards, as if to push a tight garment towards her knees. This makes traction upon the spine and straightens out the curves; flexion and extension exercises are then carried out as before.

These exercises are first performed as directed, and as the patient becomes accustomed to them and can perform them without fatigue it is useful to have them performed against resistance, the simplest way of doing which is to instruct the attendant to oppose the movements which the patient is endeavouring to carry out, gently at first, and with gradually increasing force as the muscles grow stronger. There are several forms of mechanical apparatus which are designed for the purpose of carrying out movements against resistance. Of these, Dowd's machine (see Fig. 146) is a useful type, whilst there are various other mechanical

FIG. 144.—SCOLIOSIS: POSTURAL TREATMENT. Posture described in text for correction of a scoliosis with dorsal convexity to the right.

FIG. 145.—POSTURAL TREATMENT FOR ALL FORMS OF SCOLIOSIS. The patient makes extension upon the spine by pressing the iliac crests downwards.

exercisers, such as Whiteley's, etc., in popular use. Dumb-bells are a means of doing the same thing in a minor degree.

These simple movements are suited only for cases in which there is no permanent distortion of the spine—that is to say, those in which suspension of the patient causes the spine to become perfectly straight. As these exercises produce their effect and obliterate the curve, they may be gradually abandoned in favour of more simple home-drill exercises designed to improve the muscular system generally (see p. 423); these should be practised at least once daily for a prolonged period.

A useful adjunct to this treatment is to have the child taught singing, which not only develops various muscles of the chest and back, but insures proper expansion of the lungs, tends to obliterate stooping habits, and improves nutrition generally. Adenoids or enlarged tonsils, if present, should receive appropriate treatment. Mechanical supports are never necessary in this group of cases; indeed, care should be taken to see that the patient does not wear stiff stays; the utmost that should be allowed are stays of stout jean without bones.

(β) **When the curve can be improved but cannot be obliterated.**—The treatment of this class is most difficult, because the affection has lasted long enough for bony and ligamentous changes to have occurred which prevent complete restoration; therefore the treatment must have the double object of straightening the spine as much as possible, and providing against subsequent relapses, which are very likely to occur should the treatment be abandoned prematurely.

Exercises.—The measures employed to minimise the curvature will be similar to those for the group just described, but they should be persevered with more energetically and should be carried out for a longer time and at least twice a day. Many useful ones will be found on p. 423.

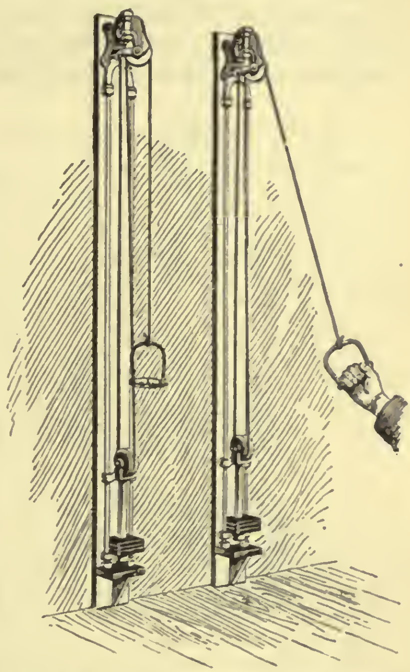


FIG. 146.—DOWD'S MACHINE. The resistance against which the exercises are performed can be increased by adding weights to the sliding brackets. Two machines are shown side by side. (*Percy Lewis.*)

Another method is the suspension of the patient from two parallel trapeze bars, one being a few inches higher than the other. The lower bar, which should be just within reach, is grasped by the hand on the side of the convexity of the curve, whilst the upper one is grasped by the opposite hand. The patient may either swing upon this or merely hang free of the ground. The object is to allow the whole weight of the body to tell upon the spine and thus to open out the curvature; this should be combined with the exercises recommended above.

Spinal Supports.—The value of mechanical supports to the spine—the so-called 'Spinal Braces'—in this class of case has been very much debated, and opinion is divided as to whether they should be employed.

In the early stages no form of brace or support is permissible which tends to keep the spinal column rigid. Such an apparatus undoubtedly supports the spine to some extent, and may therefore make the patient more comfortable and relieve him of the heavy, dull, aching pain of which he complains; but its action is most mischievous, since it is essential for cure that the muscles primarily at fault should be encouraged to perform their function of supporting the spine, and the confinement entailed by a tight-fitting jacket not only fails to effect this, but even produces actual wasting of the muscles. We are inclined to limit the use of apparatus to cases in which the curvature shows signs of increasing in spite of vigorous treatment on the lines just mentioned, or to those in which the pain is

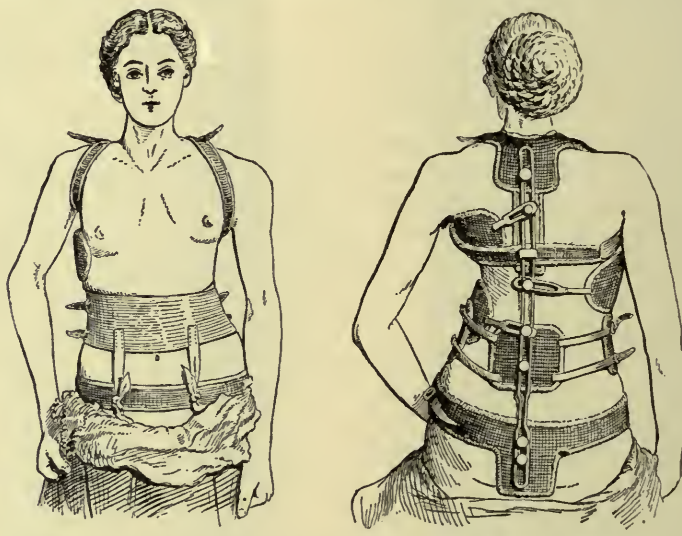


FIG. 147.—'SPINAL BRACE' FOR SCOLIOSIS. This may be taken to represent the general type. The various parts are adjustable by means of nuts. (*Percy Lewis.*)

severe and the weakness of the muscles excessive. Even then, the support should only be worn occasionally during the day, not all day long, and should be as light as is consistent with efficacy. It should be made of light steel bars taking purchase from a pelvic band, and should be furnished with suitably padded springs so directed as to apply pressure at the requisite spots—which are generally the convexity of the curve and over the angles of the ribs where they are rotated backwards. The apparatus should be so fashioned as only to support the spine when it is in a position of rest; that is to say, it should not be sufficiently tight-fitting to keep the spine immovable and therefore interfere with the proper action of the back muscles. At night no apparatus should be worn, attention being mainly directed to the posture in which the patient sleeps. A spinal brace of this kind is shown in Fig. 147. It requires careful adjustment as the curvature diminishes.

(γ) **Cases in which the curvature cannot be diminished by suspension.**—In these cases such severe changes have taken place in the spinal column that it is hopeless to attempt any rectification, and the utmost that can be done is to prevent the affection from increasing and to treat any symptoms, such as pain, that may be complained of.

Spinal Supports.—In order to prevent the increase of the curvature, a support of some kind is invaluable, and perhaps the best is a poroplastic jacket strengthened with light steel rods moulded to the thorax during extension of the spine and laced in position. This takes off the superincumbent weight of the thorax, and will often relieve the pain caused by the narrowing of the intercostal spaces or the approximation of the ribs to the crest of the ilium.

Even in these cases muscular exercises are of value, and, if carried out against resistance, are calculated to relieve the pain from which the patient suffers, by strengthening the muscles. Little hope, however, can be held out that any amount of muscular exercises or stretching of the spine will produce much effect upon the curvature. Theoretically it is possible that prolonged extension of the spine might influence its shape, but practically this is almost impossible.

The Scoliosis of Adult Life.—The condition met with here is precisely similar to that in the group of cases just described, except that the bone changes are perhaps more marked and are more permanent. The treatment is identical with that described above.

MUSCULAR EXERCISES.[1]

It is not intended that every case shall perform all the exercises. The system is intended to present rather a materia medica of exercises, from which the surgeon can prescribe those which he considers best for each case. The cases will always have a large number of symmetrical exercises, but the number and kind of asymmetrical exercises will be prescribed according to the degree and direction of the deformity.

Generally the exercises should be performed twice daily for a period not usually exceeding half an hour. Children must be made to learn the exercise gradually, two or three new ones being added at each lesson as the previous ones are learnt and well done. The chief advantage of the following system is, that the essential part of it may be done at home. Before practising the exercises, however, the patient and one of his relations, if the patient is a child, should be properly instructed by a skilled person—*e.g.* a doctor or a gymnastic master. More rapid progress is, however, made by having one of the daily lessons performed at a gymnasium, even where not more of the apparatus than would be fitted up in the patient's house is used. The patient will then be sure of having at least one lesson efficiently, properly, and regularly performed.

As the strength improves, more rapidity is obtained in the improvement by the use of the new developing machines.

The gymnasium is very advantageous, but the whole cure can be done at home, and need not interfere with lessons or any other business.

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[1] These are taken verbatim from Dr. Percy Lewis's book on *The Relief and Cure of Spinal Curvatures* (London, 1897). The small illustrative figures are derived from the same source.

All the exercises herein detailed are meant to be performed with slowness, ease, and grace, without jerking or holding the breath. No exercise is to be continued after the first feeling of fatigue is induced. There should be a rest between each, the length of which should depend upon whether the exercise has been one requiring little or much expenditure of energy. It is advisable as far as possible to interpose an exercise inducing little force between two requiring more. In the different exercises a pause should intervene in moving from one position to another, and before commencing the following exercises the patient must practise breathing properly. He must inspire as freely and deeply as possible through the nose, without strain; then, with the mouth open, expiration should follow at once without effort, being performed by the elasticity of the chest and lungs alone. Both movements should be easily and regularly performed, and a short rest should follow each expiration. After each set of three double movements there should be a longer rest occupied by at least three ordinary breaths.

N.B.—Most of the exercises down to Series G are taken from an article by Madame Nageotte-Wilbouchewitch published in the 'Presse Médicale' of October 14, 1896.

HOME EXERCISES.

These exercises commence with very mild ones and gradually work up to ones requiring more strength.

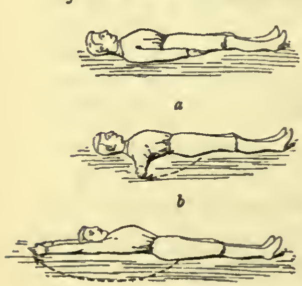
The first are performed lying down either prone or supine. The next series are made leaning against the wall or other support. The patient then performs the same exercises standing without support. This order is taken because the patients are mostly too feeble at first to do exercises standing for more than a few minutes, and therefore tend to assume bad positions. The recumbent position, as before remarked, is a good one for redressing the curves. In arranging the patient perfectly straight, some assistance may be derived from the pattern of the carpet or the lines on the floor. The upright exercises should be performed before a glass.

Dollinger, of Buda-Pesth, fixes black tapes across the glass, which then act as lines of mark. This is a very useful addition, as it enables patients to place themselves in a mesial position and easily makes evident to them any inequality of the height of the shoulders or of the sub-axillary spaces.

Series A.—Lying on the Back.

General Instructions.—The patient lies down on the floor or table, heels together shoulders at the same level, head straight, arms extended by the side of the body, palms facing upwards. The shoulder blades are to be pushed back so as to expand the chest, and the whole posterior surface of the body should be applied to the surface of the table so as to efface the lumbar bend as much as possible.

Note.—The efficacy of most of the exercises from A to F can be increased by the use of dumb-bells from half a pound to five pounds in weight.



a b c

Fig. 148.

1. *Arms in three positions.*—(*a*) By the sides of the body. (*b*) Straight out, forming a cross with the body. (*c*) By the side of the head touching the ears, and as straight as possible. Breathe while resting in each attitude. Return in the same manner to the position of rest (see Fig. 148).

These movements will exercise the pectorals, all the muscles attached to the scapula and latissimus dorsi.

2. Raise each leg to the vertical, knee kept straight; return to the position of rest, the other leg immovable. Exercise of the psoas and iliacus and quadriceps extensor (see Fig. 149).

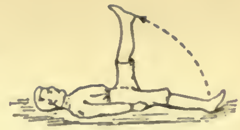


FIG. 149.

3. Bend the head to each side so that the jaw rests on the ground; return slowly to the position of rest without moving the shoulders. The arms must be kept immovable, palms upwards. Exercise of rotators and lateral flexors of head and neck.

Series B.

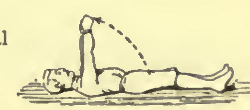
General Instructions.—Same position as above, except that in each case the movement starts from the following position: the elbows close to the side, forearm bent upon the arm, fists closed, with the thumb side to the shoulder (see Fig. 150).

FIG. 150.

1. (*a*) The length of the body (see Fig. 151, *a*). (*b*) In a cross (see Fig. 148, *b*). (*c*) Vertically upwards (see Fig. 151, *b*). (*d*) By the sides of the head (see Fig. 148, *c*).

Exercise of biceps and triceps, scapular and pectoral muscles, and latissimus dorsi.

a



b

FIG. 151.

2. Move out each leg transversely, knee kept straight, the other leg immovable, return to the position of rest. Exercise of thigh muscles and muscles passing from pelvis to great trochanters (see Fig. 152).

FIG. 152.

3. Bend the head until the chin touches the chest; return slowly to the position of rest (see Fig. 153). Exercise of sterno-mastoid, anterior neck muscles, and splenius, complexus and posterior neck muscles.

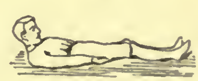


FIG. 153.

Series C.

1. *Circular turn of the arms.*—The palms upwards, the arms describe a half circle on the earth, to rejoin at the sides of the head (see Fig. 148, *c*). There the fingers cross each other (see Fig. 154), the patient stretches out as far as possible, and brings the arms back parallel to the side of the body by describing a half circle in a vertical plane (see Fig. 151, *b*). Exercise of all the muscles attached to the scapula and upper end of the humerus.

FIG. 154.

2. *Circular movement of the leg.*—The leg held straight is lifted vertically, carried outwards to the earth, and returned to its place. All the rest of the body

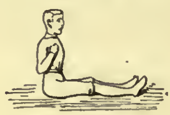
immovable. Exercise of psoas and iliacus, and all the muscles of the thigh, including those passing from the pelvis to the femur, and sartorius (see Fig. 149).

Fig. 155.

3. *Circular movement of the head.*—The head is first bent forwards until the chin touches the chest (see Fig. 153), then the head is inclined in such a manner that the ear touches the shoulder (see Fig. 155); return to the position of rest in the same level. Repeat, inclining the head to the opposite side. Exercise of the muscles on each side of the neck.

Series D.

1. Sit up without the aid of the arms, the back straight, the head stretched out (see Fig. 156, *a*). Lie down again very slowly without bending the back. Exercise of the psoas and iliacus and of anterior abdominal muscles chiefly.



a

b

c

Fig. 156.

2. Lift the legs stretched very slowly as far as the vertical. Lower them slowly. Exercise of psoas and iliacus and anterior thigh muscles (see Fig. 149).

3. Place the right hand on the ribs as high up and as far back as possible, thumb forwards. Place the left forearm on the head so that the left fingers touch the right ear. Bend all the body above the right hand as far as possible to the right (see Fig. 156, *b*). Take a few deep inspirations and return to the symmetrical position. Exercise for right dorsal curve.

4. Repeat the preceding exercise in a reverse manner. Exercise for left dorsal curve.

5. Arms in a cross. Legs and hips immovable, head straight. Bend the whole body to the left (see Fig. 156, *c*). Remain during a few inspirations. Return to the position of rest. Exercise for right lumbar curve.

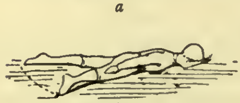
6. Repeat in the opposite direction. Exercise for left lumbar curve.

Series E.—Lying on the Stomach.

Fig. 157.

1. Arms strongly stretched at the sides, raise oneself, breathe. Exercise for erector spinæ (see Fig. 157).

a



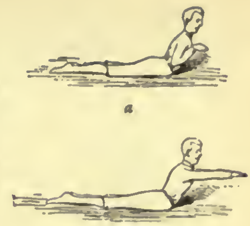
b

Fig. 158.

2. Lift each leg stretched. Perform circular movement. The head rests on the jaw of the side of the limb lifted (see Fig. 158). Exercise of thigh muscles, glutei extensors, and rotators.

Swimming Movement.

3. The palms face the ground during the whole exercise, contrary to the attitude of real swimming. The shoulder blades are not to move on the chest. The elbows and hands are not to touch the ground so as to avoid passive supporting (see Fig. 159). To rest, the patient lies down completely. Exercise for erector spinæ, latissimus dorsi, scapular and pectoral muscles.



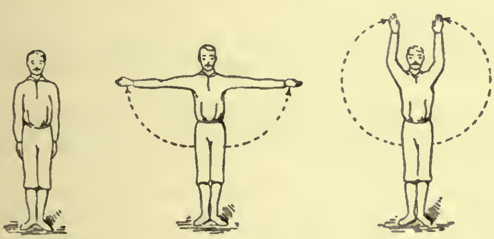
a *b*

FIG. 159.

Series F.—Exercises, done in the Upright Position with Support.

General Instructions.—The patient either simply leans against the wall, or at first is held there by a strap round the waist until he can hold himself upright without support. More muscles—viz. those required to maintain the erect posture—will be brought into play, and the exercise will thus be more severe.

1. The first three series of movements—viz. A, B, and C—are then done in this position (see Figs. 160–2).



a *b* *c*

FIG. 160.

FIG. 161.

FIG. 162.

2. Then D 3, 4, and 5 (see Fig. 163). No. 5 may, however, be carried still further in this position—viz. until the fingers touch the ground. (*a*) By placing the legs apart and bending the left knee, or (*b*) By allowing the right foot to leave the ground so that the body see-saws on the left hip joint (see Fig. 164).

a *b* *c*

FIG. 163.

FIG. 164.

Series G.—Movements made without Support.

All the movements which have been done against the wall should at last be performed without such help; also

Fig. 165.

1. *Breathing.*—Hands clasped behind the waist, inspire; hands still clasped but arms forcibly stretched downwards, expire (see Fig. 165).

Fig. 166.

2. *Flexion of trunk.*—Head straight, arms extended at sides of the head, bend the trunk forwards at the hips, so that the fingers, united by their palmar surfaces, touch the ground; return to the previous attitude with the arms in the same position. The legs to remain very straight, the feet a little apart (see Fig. 166). The repetitions of the movement to be separated by circular movements of the arms. Exercise of anterior abdominal, erector spinæ, glutei, psoas, and thigh muscles.

3. Sit down slowly upon the heels with the arms extended horizontally in front; recover to the standing position while letting the arms fall. Exercise of thigh, glutei, and erector spinæ muscles.

4. Bend the trunk forwards, backwards, laterally, and lastly circularly, the hands resting upon the hips. Exercise of anterior, posterior, and lateral abdominal muscles, and erector spinæ.

5. Separate the arms horizontally backwards as far as possible with inspiration; bring them together in front with expiration. Exercise of pectorals, scapular muscles, and latissimus dorsi.

6. *The untwisting exercise.*—Patient standing, the arms straight and horizontal, and inclined as far as possible to the right, are rapidly moved across the body as far as possible to the left; the whole spine at the same time rotating to the left. Thus the hands describe about three-quarters of a circle in a horizontal plane. Maintain this position for a few moments, then allow the arms to fall and the spine to come into a position of rest. Exercise for rotation to the right.

This is one of the most important and powerful of the asymmetrical movements. Its power is much increased by using the Dowd's machine (see Fig. 146).

7. Reverse the exercise. Exercise for rotation to the left.

8. *For poking of the chin.*—Patient sitting. Slowly bend head forwards until chin touches chest, then rapidly bend backwards as far as possible. Maintain the position a few seconds; return slowly to position of rest. Exercise of complexus, trapezius, splenius, etc.

9. Patient sitting; arms by side, simultaneously draws back both shoulders as far as possible, keeps them in this position whilst he counts four, and then allows them to return to original position. Exercise of scapular and latissimus muscles.

10. Patient sitting; bends the body on to the thighs, then slowly rises again. Exercise of anterior abdominal, psoas and iliacus, and erector spinæ muscles.

11. Patient standing opposite a wall and an arm's length from it, stretches out the arms horizontally in front, and applies the hands flat against the wall; without moving his feet the patient slowly approaches his body to the wall by bending the arm on the forearm; then he slowly recovers.

This passively expands the chest and causes contraction of the shoulder and arm muscles on both sides.

Note.—All the preceding exercises are at first made by the patient alone. By interposing resistance to the muscular effort the efficacy of the various movements can be increased at the will of the surgeon as the patient increases in strength.

12. The patient is seated in a chair with a straight back, reaching as high as the shoulders, a band fixing the trunk to the back. The patient's back and shoulders should be firmly applied to the back of the chair. A rod or stick about four feet long is then grasped firmly by the hands, about two inches or more from the ends, and raised above the head, the hands still remaining the same distance from the ends. The rod is next lowered behind the back of the chair as far as possible. The hands must still retain their position on the rod, but the elbows must be bent. Alternately raise and lower (see Fig. 167).

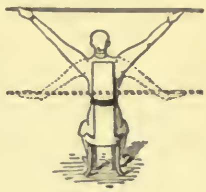


FIG. 167.

Note.—As the patient gets stronger the band will be unnecessary.

This is also a chest-expanding exercise, calling into action the muscles on front and back of the chest.

Series I.—Exercises over the Edge of a Table.

1. Lying down flat on the stomach on the table. The legs fixed by a strap across the ankles, the trunk going beyond the table as far as the hips. The arms stretched behind the back, bend the trunk down as far as the vertical, raise the head first, then recover slowly, stretching the arms forcibly and breathing deeply to the maximum of recovery (see Fig. 168). Repeat three times in succession. Rest, then repeat six times slowly. To rest, rise on to the knees on the table.

FIG. 168.

N.B.—If the curvature is bad, extension must be limited to rising to the horizontal line.

Exercise chiefly of the erector spinæ and its continuations.

2. Sit at the edge of a table with back at edge, and feet retained by a strap, then head and back straight and arms stretched behind the back, slowly lie down, breathe, return to the first position (see Fig. 169).

Note.—Until strong enough the patient must be supported through this exercise. The back must be kept straight, not rounded.

This is an exercise chiefly of the anterior abdominal, psoas, and iliacus, and front of thigh muscles.

a

b

FIG. 169.

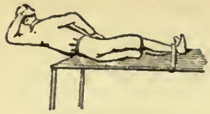


Fig. 170.

3. Same exercise lying on the side; the concavity of the principal curve downwards (see Fig. 170). It is an exercise of over-correction, which is very difficult to perform and also to teach.

Series J.—With Dowd's Machine.

Note.—In using Dowd's machine, the patient is to commence without any other weight than that of the weight-carrier. Gradually weights are added as the doctor may direct. It may, for various reasons, be found necessary to add more weights to one side than to the other. For instance, in the face-to-machine exercises for a patient with rotation to the right, it would be well to place more weights on the right side than the left. In the back-to-machine exercises greater weight on the left would then tend to untwist.

1. *Patient facing machine.*—Patient stands facing machine. Right hand straight out in front, grasping handle of machine, is made to describe a circle in a horizontal plane, being carried as far back as possible. Return to original position.

2. Ditto, left hand.

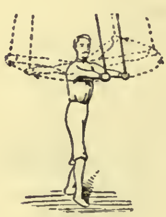


Fig. 171.

3. Same exercise, both hands together (see Fig. 171, which shows the exercise, but with the patient *back to machine*, *vide* Series K, 3).

4. Right hand held vertically up, grasping handle of machine, is brought down in front, describing a semicircle in a vertical plane.

5. Ditto, left hand.

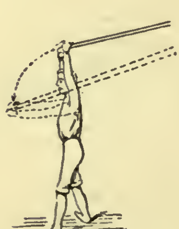


Fig. 172.

6. Ditto, both hands at same time (see Fig. 172, which is also *back to machine*, *vide* Series K 6).

7. Right hand held vertically up and straight, grasping handle of machine, is brought down at the side describing a semicircle in a vertical plane. Return to original position.

8. Left hand, ditto.

9. Ditto, both hands at same time (see Fig. 173).

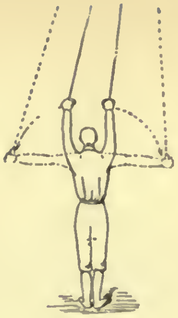


Fig. 173.

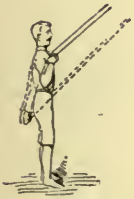


Fig. 174.

10. Elbows bent and at sides of body, both hands grasping handles, arms to be alternately straightened and returned to original position (see Fig. 174).

11. Arms straight out in front, hands grasping handles, bend elbows and bring them back until they come to sides of the body; hands remain straight out. Alternately repeat and return to original position.

12. Incline head towards machine, grasp one handle with both hands and hold it in contact with back of the head. Bend head as far back as possible from the neck, carrying handle and hands with it. Alternately repeat and return to original position (see Fig. 175).

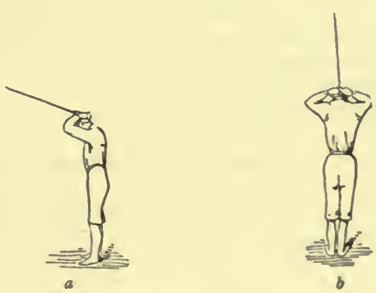


Fig. 175.

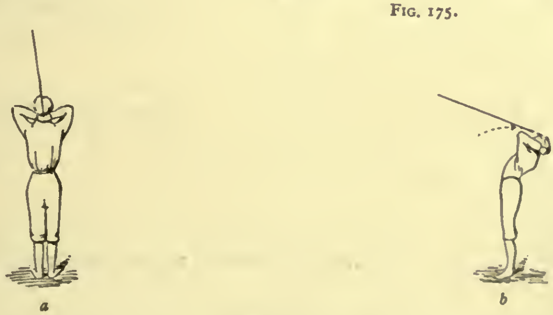


Fig. 176.

13. Same exercise, but bending back and neck as far back as possible (see Fig. 176).

FIG. 177.

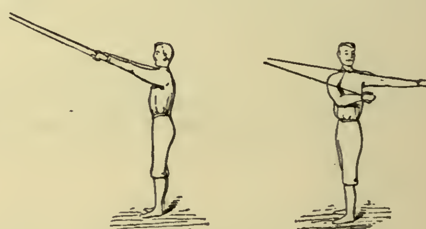
14. Patient erect, holding handle and hands in same position ; bend forwards, bringing head as low as possible. Return to original position (see Fig. 177).

15. Right arm straight out from side, hand grasping handle. Hand describes a circle about a foot in diameter, its first position being the centre.

16. Ditto, left arm.

17. Ditto, both arms at same time.

18. The untwisting exercise, Series G, 6 (see Fig. 178).



a *b*

FIG. 178.

19. Ditto, Series G, 7.

20. Right arm straight out in front, the hand grasping handle is carried vertically upwards, then outwards, downwards as far as possible, and finally returns to original position after describing a circle.

21. Left arm ditto.

22. Both arms together ditto.

Series K.—Patient with Back to Machine.

1.	Series	J,	Number	1,	reversed.	
2.	,,	,,	,,	2,	,,	
3.	,,	,,	,,	3,	,,	(See Fig. 171.)
4.	,,	,,	,,	4,	,,	
5.	,,	,,	,,	5,	,,	
6.	,,	,,	,,	6,	,,	(See Fig. 172.)
7.	,,	,,	,,	7,	,,	
8.	,,	,,	,,	8,	,,	
9.	,,	,,	,,	9,	,,	(See Fig. 173.)

FIG. 179.

10. Series J, Number 14, reversed (see Fig. 179).

11. Series J, Number 16, reversed.
12. ,, ,, ,, 16, ,,
13. ,, ,, ,, 17, ,,
14. ,, ,, ,, 20, ,,
15. ,, ,, ,, 21, ,,
16. ,, ,, ,, 22, ,,

Series L.—Side to Machine Exercises.

1. Right side to machine; arm straight out grasping handle is carried upwards to side of head; returns to first position, pauses, and is brought down to side; reverse; repeat.

2. Left side to machine; same exercise for left arm.

3. Right side to machine; left forearm resting on head, left hand over right ear grasping handle (see Fig. 180). Patient leans as far as possible towards machine, recovers and leans as far as possible away from it; hips and legs immovable (see Fig. 181).

Fig. 180.

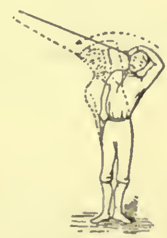


Fig. 181.

4. Repeat with left side to machine, right arm over head.

5. Repeat 3, with a circular instead of a to-and-fro movement.

6. Repeat 4, with a circular instead of a to-and-fro movement.

Note.—It will be seen that most of the exercises with Dowd's machine are chiefly the previous exercises performed with apparatus. The machine simply is an accurate means of adding increasing resistance by putting more weights on to the carrier. The same remarks apply more or less to all the developing machines hereafter mentioned.

Series M.—Exercises with a Single Dowd's Machine, the Rope passing under a Pulley attached to the Floor. (Face to Machine.)

1. Right arm obliquely in front holding handle. Raise to the vertical by side of head without bending arm.

2. Left arm ditto.

Fig. 182.

3. Both grasping handle at same time (see Fig. 182).

4. Right arm obliquely in front, raise forearm as far as possible without moving upper arm.

5. Left arm ditto.

Fig. 183.

6. Both together ditto (see Fig. 183).

7. Right arm obliquely in front, grasping handle, is carried backwards as far as possible, and allowed to return to original position.

8. Left arm ditto.

9. Both together ditto (see Fig. 184).

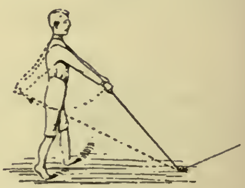


Fig. 184.

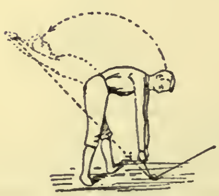


Fig. 185.

10. Arms straight out in front, both hands grasping handle, body bent forwards as far as possible, is raised and carried backwards as far as possible, arms remain straight (see Fig. 185).

Series N.—With Single Dowd as for Series M, but instead of a Handle the Rope is fixed to a Strap which is fastened to each foot in turn. (For Right Foot.)

1. Facing machine, right hand resting on back of a chair, leg straight is alternately carried forwards and backwards (see Fig. 186).

Fig. 186.

2. Similar exercise with back to machine.

Fig. 187.

3. Facing machine, right hand resting on back of chair, leg is brought from being in a line with left as high up as possible by bending the knee. Thigh remains immovable (see Fig. 187).

4. Left side towards machine, left hand on back of chair, the left leg is alternately in front of right as far as possible to right, and returned to original position (see Fig. 188).

FIG. 188.

5. Left side towards machine, the right hand on back of a chair, the right leg is carried from contact with the left as far out as possible (see Fig. 189).

FIG. 189.

FIG. 190.

6. Left side to machine, right hand on back of a chair, left leg held obliquely outwards towards the machine, thigh immovable, the left knee is bent until the foot touches the right leg (see Fig. 190).

7. Patient seated right side to the machine, the left foot is alternately turned outwards and allowed to recover.

FIG. 191.

8. Reverse exercise by turning left side to machine (see Fig. 191).

9. Same as 1, reversed.
10. „ „ 2, „
11. „ „ 3, „
12. „ „ 4, „
13. „ „ 5, „
14. „ „ 6, „
15. „ „ 7, „
16. „ „ 8, „

Exercises for the Medical Gymnasium.

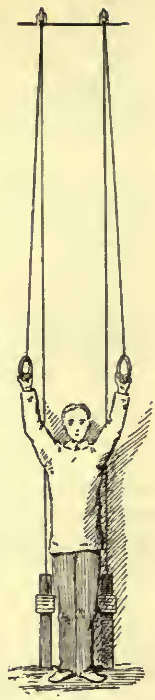


FIG. 192.

Note.—Any of the exercises for Dowd's machine may be performed with any of the modifications of it. Thus the high Dowd's (see Fig. 192) may be used in the same way, where it is required to develop especially the lower part of the chest, to help the latissimus dorsi and the lower part of the serratus magnus, trapezius, pectorals, etc., in their elevating action on the lower ribs.

The Quarter-circle Dowd (see Fig. 193) will be especially useful in stooping and posterior curves of the spine.

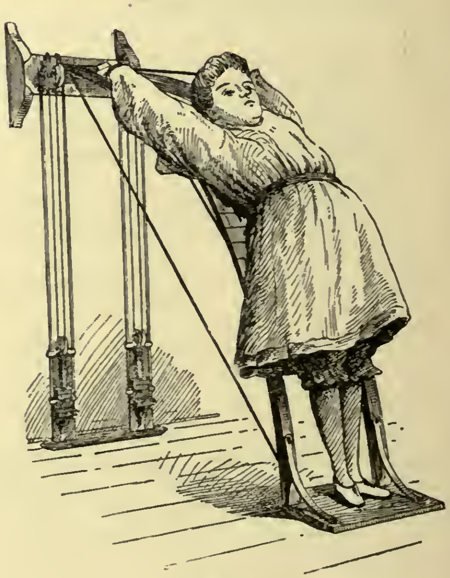


FIG. 193.

The rowing machine (see Fig. 194) is a very powerful combination of all the Dowds, only to be used towards the end of the course. It exercises practically all the muscles of the body.

Fig. 194.

Series O.—Wheel Exercise.

1. Patient standing with back to wheel, arms out in a cross grasping the projecting pegs. See-saw action, to and fro (see Fig. 195). Increase resistance according to the patient's strength.

Fig. 195.

2. Right side to machine, left hand on left hip, right hand grasping peg at summit of circle, right foot forwards, spine stiff. Right hand turns wheel from above downwards.
3. Same, left foot forward.
4. Same as 2, reversed.
5. Same as 3, reversed.
6. Right side to machine, feet together, right hand grasping lowest peg, left hand passing over head grasps highest peg, right hand to move forwards, left hand backwards.
7. Same, reversed.

EXTENSION EXERCISES FOR ACTING CHIEFLY ON THE SPINAL LIGAMENTS.

Series P.—Oblique Ladder.

1. Patient on back, feet on lowest two rungs, hands on highest rungs he can reach. Raise feet to the rungs of next level, the hands bearing the weight meanwhile. Remove the feet from the rungs for a few seconds so that hands bear all the weight. Raise feet to next level, and so on until the top is reached. Come down in reverse order.
2. Ditto, with right arm always one rung above the left.
3. Ditto, with left arm always one rung above the right.

Series Q.—Exercises with Parallel Rings.

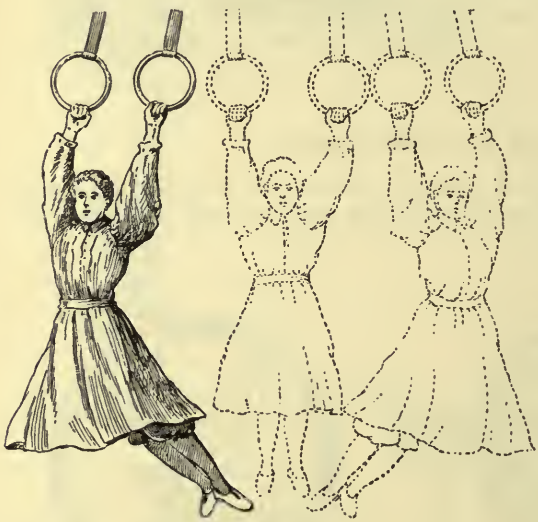


Fig. 196.

1. Patient stands between rings, which are suspended about a foot above his head, and, keeping feet fixed as a pivot, performs a circular movement of the whole body, from right forwards to left; from left backwards to right (see Fig. 196).
2. The rings may be gradually lowered.
3. Right ring may be a few inches higher than the left.
4. Left ring may be a few inches higher than the right.

Series R.—Vertical Pole or Rope.

Note.—This exercise is best performed with the pole or rope rigid or suspended against a wall.

1. Patient standing with back to pole, the hands above head, grasps the pole as high as possible; then, raising the heels from the ground, the patient endeavours, with one hand at a time, to grasp the pole just above the other hand. The patient then allows the hands to bear the weight in endeavouring to get the heels again on to the ground.
2. Same exercise, right hand always higher.
3. Same exercise, left hand always higher.

Series S.—Trapeze.

1. Patient standing on a stool, trapeze at such a height that the patient can just reach it with hands above head. Patient grasps trapeze, stool is removed, and patient swings backwards and forwards by alternately flexing and extending his legs.

Series T.—Vertical Ladder or Gridiron.

1. Same as Series P, 1.
2. Same as Series P, 2.
3. Same as Series P, 3.
4. Right foot on one of the lower rungs, right hand on one of the upper, so that the right side of the body forms a concavity towards the ladder. Alternately stretch left arm and left leg as far to the left as possible, and allow them to return to the hanging position.
5. Ditto, reversed.
6. Climb with back to ladder using only left hand, right carrying a weight.
7. Same, with face to ladder.
8. Same as 6, left hand carrying a weight.
9. Same as 7, left hand carrying a weight.

Series V.—Dumb-bells.

1. Holding dumb-bell of five pounds or more at level of shoulder in right hand. Alternately raise and lower.
2. Ditto, with left hand.

Series W.

1. Alternately raise above head and lower a heavy steel bar, using both hands. The patient should fix his eyes on the centre of the bar.

APPENDIX

ANÆSTHETICS

BY

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AND

THE EXAMINATION OF THE BLOOD IN SURGICAL CONDITIONS

BY

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ANÆSTHETICS.

By Dr. J. F. W. SILK.

The abolition of pain, quietness, muscular relaxation, and the diminution of shock are the chief objects we have in view in placing a patient under an anæsthetic. To attain these ends, no method is so certain and so universally applicable, as that of *general anæsthesia* by inhalation, the patient being rendered unconscious. It may sometimes be undesirable to subject the patient to the comparatively slight dangers and discomforts of a general anæsthetic, but to limit the anæsthesia to the area to be operated upon. In such cases *local anæsthesia* may be employed.

PART I.

GENERAL ANÆSTHESIA.

PRELIMINARY OBSERVATIONS.

Preparation of the Patient.—With the possible exception of nitrous oxide (see p. 448), an anæsthetic is always taken better if the patient has been subjected, for a few days, to what may be termed **hospital regime.** This does not of necessity mean absolute confinement to bed, but it implies rest of body and mind, careful regulation of the ordinary bodily functions, light and easily digested diet, and abstention from alcohol. Young children and highly neurotic adults are often best kept in ignorance of an impending operation, but such patients frequently give trouble under an anæsthetic, and so confirm the value of the general rule.

It has been suggested that a course of some such drug, as strychnine, quinine, iron, etc., should be given for a few days before the operation, with a view to obviating some of the difficulties and dangers which may arise during the administration of an anæsthetic. The tonic properties of such substances are, no doubt, of value, but it has not yet been proved that any of them possess a specific action in the matter.

A **purge**, in the shape of castor oil, compound liquorice powder, calomel, colocynth, or compound rhubarb pill, is usually given the night before the operation, and, if necessary, an enema in the morning; this may consist either of plain water or soap and water. The latter is made by rubbing up Castile soap in warm water until a thick lather is formed, and about a pint is injected.

Diet.—It is important that the stomach should be empty before the inhalation commences; but starvation may be carried too far, especially in the feeble. Each case should be treated upon its merits, according to the digestive capacities and general health of the individual, and bearing in mind that the mere dread of the operation will often retard the digestion for hours. The **best time for operating** is the early morning, in which case no food need be given after supper on the previous evening. If the operation be fixed for the afternoon (at or after 1 P.M.), a light breakfast should be taken not later than 8 A.M., and a cup of hot broth or beef tea, or even hot water alone, should be given not less than three hours before the actual time of operation; this is useful in counteracting the feeling of exhaustion and faintness, of which many persons complain if kept fasting too long. Milk and other slowly digestible substances should be avoided.

In cases of special gravity, either from the condition of the patient or the probable severity of the operation, it will be found useful to give, when possible, a **nutrient enema** (yolk of one egg, one ounce each of beef-tea, milk, and brandy, peptonised,[1] if the patient be particularly exhausted) half an hour before he is placed upon the table, care being taken to wash out the rectum with warm water before the enema is injected.

Alcohol.—Physiologically or clinically considered, the use of brandy by the mouth is irrational, as it encourages the tendency to retching and vomiting, and increases the poisonous effects of the anæsthetics. It may become necessary, however, in cases of impending syncope, and in some few instances its administration may have a good moral effect, but, as a general rule, it is not desirable.

Hypodermic medication, immediately before the inhalation, has been advocated, the drugs most frequently employed being morphine, atropine, scopolamine, strychnine, and digitaline. Morphine ($\frac{1}{6}$ to $\frac{1}{4}$ grain) is said to diminish shock, and to make it possible to keep the patient anæsthetised with a weaker vapour than might otherwise be necessary; it is claimed

[1] To peptonise, add 15 gr. bicarbonate of soda and a dessertspoonful of Benger's Liquor Pancreaticus or 5 gr. of Fairchild's Zymine. Place the jar containing the mixture in a basin of water as hot as the hand can bear. Allow it to remain for half an hour, then heat it quickly to boiling point for one minute. Cool for injecting.

for atropine ($\frac{1}{100}$ grain with or without morphine) that it prevents cardiac inhibition, and, by checking the flow of saliva and mucus, averts after-sickness. Scopolamine ($\frac{1}{100}$ grain) is used, alone or with morphine ($\frac{1}{6}$ grain), to produce a state of stupor or semi-narcosis which, it is said, renders the use of an anæsthetic vapour nearly superfluous; a dose of the combined drugs is given on the previous evening, and this is repeated on the morning of the operation. Digitaline may be given as a cardiac tonic when required ($\frac{1}{100}$ grain). In my experience the advantages of these drugs is rather more theoretical than practical, and the use of them as a matter of routine is open to the objection that they tend to mask the ordinary symptoms of over-narcosis. There seems to be some reason for believing that **strychnine** is of considerable value in obviating or diminishing what may be termed 'operation shock,'[1] and it is also claimed by some that the tendency to sickness is lessened by its use. In the feeble, therefore, and in severe operations, $\frac{1}{30}$ grain may be injected, either immediately before or immediately after anæsthesia is induced, and the dose may be repeated once or twice during the course of the operation; this does no harm, and may do a great deal of good.

Before the inhalation is commenced, every care must be taken to remove anything that may interfere in the slightest degree with the most **absolute respiratory freedom**; even in normal sleep the least pressure on the chest may cause an immense amount of discomfort. Plugs of tobacco, artificial teeth, obturators, etc., should be removed, lest they fall or get pushed into the larynx or pharynx; collars, stays, belts, waistbands, braces, or bandages, must be completely relaxed.

In some instances, **auscultation** of the chest and heart increases the trepidation of the patient, and, in by far the majority of cases, the information obtained is valueless or misleading. On account of nervousness the rate and rhythm of both cardiac and breath sounds are much interfered with, and the accurate detection of slight lesions becomes almost impossible. Although auscultation is not to be recommended as a routine practice, the anæsthetist is bound, nevertheless, to acquaint himself, through the medical attendant, or through the patient and his friends, with all points in the medical history of the case which may have any bearing upon the question of the anæsthetic, especially in connection with the respiratory and circulatory systems; in cases of doubt, or if the slightest desire for it be manifested by the patient or his friends, a careful examination should, of course, be undertaken. It will probably help to calm the patient if the pulse be felt, although, for the reasons indicated above, but little real information is gained, beyond detecting any marked thickening or atheroma of the arterial walls.

[1] Prof. Wood of Philadelphia, *Transactions of the International Medical Congress*, Berlin, 1890, vol. i. p. 133.

The **position of the patient** on commencing the inhalation must vary slightly under different circumstances. Fussy attempts to 'arrange' the patient are to be deprecated, and, generally speaking, the best rule to adopt is, to allow the patient to assume the recumbent posture most convenient and comfortable to himself. In most instances this will be supine, when, especially if there be any tendency to emphysema, the head and shoulders should be well supported with pillows. With the patient sitting up (nitrous oxide or ether), care must be taken that the head is placed in such a position that the tongue does not fall back over the glottis. In some few cases, the patient naturally assumes the lateral position, and in this the anæsthetist should acquiesce. The great object in view is, to make the necessarily disagreeable, preliminary stages, as short, and as little unpleasant as possible. In mouth and throat cases it is sometimes desirable that the body should be raised to an angle of 45°. To this I see no objection, provided that the legs are kept horizontal.

The Choice of the Anæsthetic.—To a considerable extent the comfort of both patient and operator, and to some extent the actual safety of the patient, depends, not only upon the skill of the administrator, but also upon the particular anæsthetic used. As far as the choice of the anæsthetic is concerned, the patient, the operator, and the anæsthetist himself are all factors which have to be considered before making the final selection, so that it is almost impossible to do more than lay down very general rules ; each individual case must be decided upon its own merits.

In the first place, it is obvious, that rules that are intended for those with whom it is not a matter of absolutely every-day experience to administer an anæsthetic cannot have the same weight when applied to the specialist. An example of this is seen in the use of ether. When plenty of practice in the administration of this drug is obtainable, it may be given in the majority of cases ; but, on the other hand, when only used very occasionally, the results are apt at first to be disappointing, unless the cases are carefully selected. In the second place, some surgeons object to the use of particular anæsthetics in certain operations ; for example, some surgeons consider that chloroform alone should be given in all cases of abdominal section. Under these circumstances, it is probably to the best interests of the patient to adopt the views of the surgeon ; the latter ought not to be allowed to feel, or even to imagine, that his work would have been better done, had a different anæsthetic been used. In the third place, it may be laid down as an axiom, that it is unwise to employ a stronger anæsthetic than is absolutely necessary. The relative strength of the various substances may be assumed to be as follows, commencing with the most feeble, viz. : nitrous oxide, ether, diluted chloroform (as in the A.C.E. and other Mixtures), pure chloroform and ethyl chloride.

Factors determining Choice of Anæsthetic.—In choosing an anæsthetic, the most important of the determining factors are those which concern the patient and the nature and probable duration of the operation to be performed ; these must, therefore, be considered more in detail. A distinction, too, must be drawn between the anæsthetic with which it is advisable to induce or commence the anæsthesia, and that with which it is possible to maintain or continue it.

(1) *Duration of the Operation.*—Either nitrous oxide or ethyl chloride is available in operations of under three minutes. These include such operations of minor surgery as opening superficial abscesses, dilating and slitting up sinuses, some tenotomies, removing small aural polypi, passive movement of stiff joints, and, of course, the extraction of teeth.

(2) *Position of the Patient.*—Neither chloroform, nor any mixture containing that drug, should be used with the patient sitting up in a chair ; such a proceeding is *absolutely unjustifiable.* Operations upon the cerebral hemispheres, and upon the mouth and tongue, do not really constitute exceptions to this general rule, for although the body is then often raised, the feet and legs remain horizontal.

(3) *Age of the Patient.*—Some anæsthetists see no objection to the use of ether at any age, while others prefer to induce narcosis with chloroform in the very young, and continue with ether afterwards. Until sufficient facility in the use of ether has been acquired, and unless one has constant practice with the drug, it is better to adopt some such age-limits as the following:

Under 3 years of age . .	Chloroform all through.
From 3 to 12 . . .	Mixture all through.
From 12 to 60 . . .	Ether all through.
Over 60	Induce with Mixture, increasing the proportion of ether in long operations.

It is usually asserted, somewhat dogmatically, that children always take chloroform well. It must not be forgotten, however, that many accidents have occurred, and that in the opinion of some people the death-rate with children is as high, or even higher, than with adults. This *apparent immunity of children* from fatal accidents under chloroform is due to many causes, among which may be mentioned the undoubted fact that, owing to their greater vitality, children respond more readily than adults to any efforts that are made in the direction of resuscitation.

(4) *Condition of the Patient.*—Here, again, some anæsthetists admit of but few exceptions to the use of ether, only perhaps acute lung troubles, but, at first at any rate, better results will be obtained if the range of exceptions is somewhat enlarged.

In the fat and plethoric . .	Induce with Mixture and gradually increase the proportion of ether in long operations.
Acute or very recent lung troubles	Chloroform all through.

Chronic lung trouble (bronchitis or emphysema	Mixture all through.
Organic heart disease	If insufficiently compensated (pulmonary œdema, anasarca, albumen, etc.), Mixture, or chloroform. If fully compensated, ether permissible.
Marked Atheroma	Induce with Mixture; add a little ether if the operation be a prolonged one.
Renal Disease	Mixture all through.

Alcoholics take all anæsthetics badly. In acute or advanced cases it is, perhaps, better to commence with Mixture, and gradually increase the proportion of ether as the case proceeds.

(5) *Nature of the Operation.*—To a great extent, the influence of the nature of the operation upon the choice of the anæsthetic must be largely determined by the opinion of the surgeon upon the subject. It is, therefore, a point of no little importance that the latter should have complete confidence in the administrator. The careful selection of the administrator is a question of the greatest moment, and not to be dismissed lightly; to take any one that offers is very unjust to the patient, and accounts for many of the troubles and fatalities which are from time to time recorded.

Operations upon the head and neck	Mixture to induce, increasing the proportion of ether in long operations.
Intra-cranial operations	Chloroform or Mixture all through.
Operations upon the tongue and mouth	Induce with Mixture; change for chloroform directly operation commenced.
Operations on big joints	Always ether, if possible.
Abdominal operations	Often do well with ether, but chloroform or Mixture generally preferred by surgeons.
Rectal and genito-urinary operations	Always ether, if possible.

In practice, the choice of the anæsthetic may be quickly determined by adopting a process of exclusion, taking the different substances in the order of their relative strength, as given on p. 446.

ADMINISTRATION OF NITROUS OXIDE.

Properties.—The chemical constitution of Nitrous Oxide is sufficiently indicated by the formula N_2O. It is a gas, but is usually sold in a highly compressed, liquid form, in steel or iron bottles (Fig. 197, *A*). The gas, when pure, should be quite colourless, of a slightly sweetish taste and odour, and unirritating to the air passages. It is a feeble anæsthetic, and is usually given without any admixture with air, *i.e.* 100% of the vapour. When sufficient skill has been attained in the use of Nitrous Oxide in the ordinary way, it will be found advantageous to allow the admixture of small quantities of air during its inhalation, but this requires much practice.

Cases Suitable.—Broadly speaking, anyone can take nitrous oxide with comparative safety, but I object myself to giving it to very young children. It is better, perhaps, not to administer it within an hour or so of a full meal, and care should be taken that the bladder is empty, especially in children, but otherwise, no special preparation is needed, beyond that which is necessary to ensure free respiration (see p. 445). It is most frequently given with the patient sitting straight up in a chair, with the head in such a position that the tongue does not slip back over the glottis; it may, of course, be given with the patient recumbent. For the cases in which it is specially applicable, see sec. (1), p. 447. In dental work, and in operations about the mouth, it is usual to insert a prop of wood or cork between the teeth before applying the facepiece.

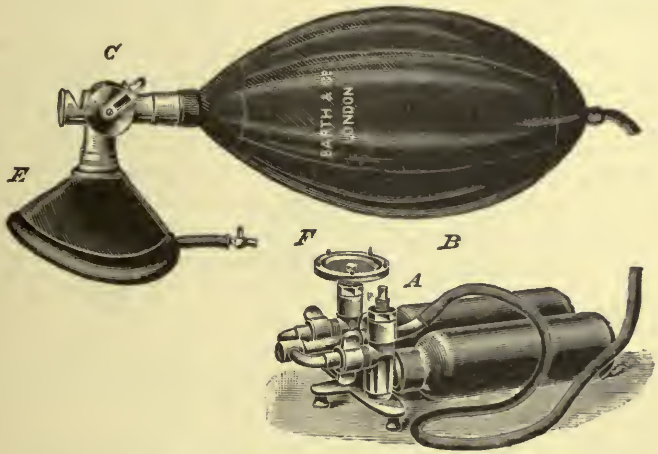


FIG. 197.—NITROUS OXIDE APPARATUS. *A*, Steel bottles containing compressed gas in liquid form; *B*, Reservoir bag; *E*, Facepiece; *F*, Footpiece for regulating escape of gas from the bottles into reservoir bag; *C*, Three-way stop-cock with inspiratory and expiratory valves.

Although in some respects an ideal anæsthetic, there are many **limitations to its use**; the most important of these is that, owing to its feeble anæsthetising power, it is difficult to maintain the narcosis for any length of time, and practically, therefore, its administration is limited to cases in which the single application of the facepiece will suffice. On an average, this represents between 30 and 40 seconds, but, with a little careful manipulation and an occasional supply of air, provided that the operation is not upon the mouth, this time can easily be doubled or trebled. Another objection to it is, that the relaxation of the muscles is usually very transitory, and, when the inhalation is pushed, there may be actual spasm; in moving stiff joints, therefore, it is of importance not to continue the inhalation for too long a time without admitting air.

Apparatus and Administration.—To ensure the complete exclusion of air, the somewhat complicated apparatus, shown and described in Fig. 197, is used. The bag *B* being filled with gas, the administrator stands either behind or on the left side of the patient, and carefully adjusts the facepiece *E* to the irregularities of the face. Being satisfied that there is no air leakage, the stop-cock *C* is turned half-way; the nitrous oxide is then inspired from the bag, and expired through the valves contained in the stop-cock into the open air.

Phenomena.—After a very few respirations the colour of the face commences to change, becoming more and more dusky, or uniformly livid. Gradually, too, the breathing becomes harsher, and changes to a regular snore, which, in its turn, gives place to an irregular, jerky, **laryngeal stertor**; at or about the same time, or sometimes even before the laryngeal stertor is noticed, **twitching** of the superficial muscles of the eyelids, mouth, neck, etc., or of the tendons of the thumbs and fingers will be seen; and, if the inhalation were to be continued beyond this, well marked jactitation of the limbs, or even opisthotonic spasm of the whole body, would result. Usually, but not always, the pupils dilate, and the conjunctivæ may become insensitive to touch, but the eye reflex is not a reliable sign of the sufficiency of the anæsthesia. Whichever is first observed, the irregular laryngeal stertor, or the twitching of the muscles and tendons, is the indication for withdrawing the facepiece. After the facepiece has been withdrawn, the first few breaths of air are followed by a reactionary redness or blush about the face, etc., and this is an important landmark for the administrator; not until it occurs is he quite free from anxiety.

Complications.—The action of nitrous oxide is really remarkably uniform, and complications rare; but accidents have happened, and deaths have occurred both from syncope and asphyxia. It should be a rule, therefore, to keep a finger on the temporal pulse, both during the inhalation, and until the reactionary flush occurs; if the pulse disappear, the patient should be at once put in the recumbent position, and the ordinary treatment for syncope adopted. Asphyxia may be due to a foreign body, *e.g.* a tooth, and it also seems likely to occur in patients suffering from acute inflammation of the fauces and trachea. In asphyxiated patients, the first thing to do is to pass the finger well to the back of the throat to free the air-way, and to attempt to remove any foreign body that may be felt. Failing this, the patient should first be bent sharply forward, and encouraged to cough by patting the back, etc.; if this does not give relief, he must be taken out of the chair and laid upon his side on the floor, and, if this fails to relieve the asphyxia, tracheotomy, or, better, laryngotomy must be done. Hysterical patients sometimes give trouble from the beginning by struggling and screaming; this is best overcome by compressing the reservoir bag, and so forcing the gas into the lungs, taking care, of course, to cut off the action of the valves in the stop-cock. Children and anæmic girls are apt to pass quickly and deeply under the influence of the gas, and to become opisthotonic; the facepiece, therefore, should be removed immediately the slightest twitching or stertor occurs.

The **after-effects** of nitrous oxide may be said to be practically nil, and this is one of its great advantages. Neurotic patients are sometimes hysterical, very rarely there is a little sickness, but, in by far the majority of cases, the patient is quite able to leave the house, or walk about within ten minutes or a quarter of an hour of the inhalation.

PROLONGED NITROUS OXIDE ANÆSTHESIA.—Various plans have been suggested for increasing the anæsthetising power of nitrous oxide gas. In operations not involving the mouth or nose, the anæsthesia may often be much prolonged by allowing the patient an occasional breath of air directly the twitching appears. In dental and other mouth cases, the supply of nitrous oxide may be maintained by means of a cap fitted over the nose, as suggested by Coleman and Paterson (see Fig. 198). Of late years I have employed this method almost as a matter of routine for women and children, not only to maintain, but also to induce anæsthesia for dental work. The mouth is propped open, the cap fitted over the nose and a slight plus pressure is maintained in the bag. Contrary to what might be expected, anæsthesia is apt to be induced, if anything, too rapidly and the patient must be carefully watched. In adult males, and in some fat, flabby females who breathe badly through the nose, the inhalation should be started with the ordinary facepiece, quickly changing the latter for the nosepiece directly the twitching develops. On the whole I have found this plan extremely satisfactory. Other forms of apparatus for this purpose have been introduced by Trewby and others.

FIG. 198.—PATERSON'S NOSEPIECE. A, Three-way stopcock and valves. C, Nosepiece.

Adopting the view that the lividity, muscular twitching, and some of the other phenomena are indications of oxygen starvation, and, assuming that these phenomena are always objectionable, it has been proposed to administer a mixture of nitrous oxide and oxygen. In the apparatus that Sir Frederic Hewitt has designed the nitrous oxide and the oxygen are contained in separate bags, and provision is made for very gradual admixture of these gases through small holes in the stop-cock. The facepiece being accurately adjusted, the nitrous oxide mixed with the oxygen from one or two holes is breathed from the beginning, and the

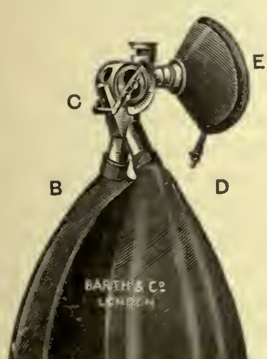


FIG. 199.—HEWITT'S 'GAS AND OXYGEN' APPARATUS. B and D, double bag for oxygen and nitrous oxide. C, three-way tube fitted with small holes for regulating supply of oxygen. E, facepiece.

amount of oxygen is increased by a hole or two at a time as the inhalation proceeds. The indications for removing the facepiece are a faint stertor, fixation of the eyeball, and insensibility of the conjunctivæ. The method is most suited for elderly or anæmic subjects or those whose circulatory or respiratory systems are feeble, but the apparatus is cumbersome, and unpleasant after-effects are rather more likely to follow than when nitrous oxide is administered in the ordinary way.

The period of available anæsthesia may also be prolonged by mixing the gas with some other and more powerful anæsthetic, such as ether. This is what is known as the 'combined' or 'gas-and-ether' method of anæsthesia, which will be referred to after the administration of ether has been described (see p. 457).

ADMINISTRATION OF ETHER.

Properties.—Ethylic or sulphuric ether ($C_4H_{10}O$) is a liquid of which the *spec. grav.* should be 0·720; it is neutral to test-paper, and leaves neither stain nor smell when burnt off or evaporated. It is usually recommended to employ only that made from absolute alcohol; but many excellent brands are now on the market, which, if carefully selected, seem unobjectionable. The so-called 'anæsthetic ether' of chemists is intended only for freezing, and should never be used for inhalation. Ether vapour is highly inflammable, and even explosive when mixed with air or nitrous oxide. Over 30 per cent. of the vapour is necessary to produce narcosis within a reasonable time.

Cases Suitable.—It is considered by many that ether should be employed whenever an anæsthetic is called for; practically, the only exceptions which are then admitted are those in which bronchitis or some other acute lung trouble is present, or when, as in operations about the mouth, it is either physically impossible to apply the facepiece, or else there is some danger that the actual cautery will ignite the vapour. For the reasons given above (see p. 446), this universal use of ether is at first likely to prove disappointing to those not thoroughly accustomed to the drug. When only occasionally called upon to anæsthetise, it is better for the administrator to limit his use of ether in accordance with the suggestions already made (see p. 447). If these lists be carefully studied, it will be seen that ether is *not* recommended for children under twelve, or for adults over sixty; nor for the fat and plethoric; nor for those suffering from gross cerebral lesions; nor in cases of lung disease; nor in acute heart disease, atheroma, or renal disease; nor in operations about the head and neck, mouth and tongue. At first sight, it may appear that this list of exceptions reduces the available cases to a minimum, but in practice this will not be found to be the case, and, further, it must be pointed out, that in by far the majority of cases the objection applies rather to the primary *induction*; in nearly all it is possible to use ether to *maintain* the anæsthesia.

Ether should always be given, if possible, in cases involving much shock, and in which a profound degree of narcosis is required, as in operations about the rectum, on the genito-urinary tract, or on big joints. Operations upon the abdomen are on the border-line, and the anæsthetic chosen must be largely determined by the predilection of the surgeon (see p. 446).

With regard to the **preparation** of the patient, nothing need be added to what has already been said upon the subject (see p. 443). It is one of the advantages of ether, which is sometimes overlooked, that, if need be, it can be administered to a patient sitting up, without much additional risk; preference should, however, always be given to the recumbent **position**, as the increased muco-salivary secretion can then be got rid of more easily.

Apparatus and Administration.—In an emergency, an inhaler for

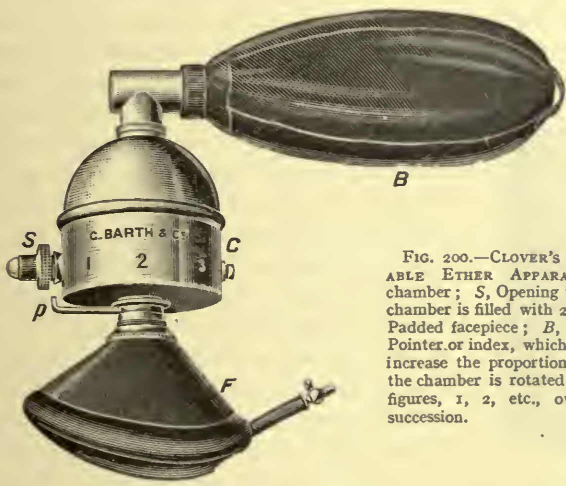


Fig. 200.—Clover's Small or Portable Ether Apparatus. *C*, Ether chamber; *S*, Opening through which the chamber is filled with 2 oz. of ether; *F*, Padded facepiece; *B*, Reservoir bag; *p*, Pointer or index, which is a fixture. To increase the proportion of ether inhaled, the chamber is rotated so as to bring the figures, 1, 2, etc., over the index in succession.

ether can be made by twisting two or three folds of brown paper into a cone, like a grocer's sugar-bag, pushing a wide-meshed sponge well up into the apex of the cone, and tearing off the extreme tip to admit air; the ether is poured upon the sponge. Of course, better results will be obtained when a properly constructed inhaler is used. In Fig. 200, the well-known **Clover's** (small and portable) **Inhaler** is shown. Two ounces of ether are poured into the ether chamber through the opening *S*. The inner tube, with the facepiece attached, is thrust up through the corresponding opening in the ether chamber, the index *p* carefully adjusted to the mark 0 on the body of the chamber, and the facepiece *F* placed over the mouth and nose of the patient. After a few breaths have been taken, and the patient has become accustomed to the apparatus, the bag *B* is fixed to the end of the inner tube which will be found flush with the upper opening in the ether chamber. A few breaths in and out of the bag are allowed, and then, during an expiration, the body of the chamber is gently rotated, either to the right or to the left, for the space of about a quarter of an inch, or even less; a few more breaths being allowed, another rotation of about the same extent is made. These movements are repeated at short intervals until, finally, the index points to about the 2, at which position it is maintained until a sufficiently profound degree of narcosis is obtained. Each movement of the ether chamber should be made during an expiration, and no additional onward movement should take place so long as there is any coughing, spasm, or other indication that the vapour is producing irritation. It is seldom, if ever, necessary to give a greater strength of vapour than that indicated above, and, in fact, when the primary skin incisions have been made, and the patient has become quiet, and saturated with ether, it is, advisable to diminish the strength of the vapour by turning the ether chamber back towards the 1, or even to remove the bag altogether.

The Open and Semi-open Methods.—Of late years some administrators have urged that better results are obtained by dispensing altogether with the bag, and simply spreading the ether over an evaporating surface held just above the nose and mouth. In America, where this practice is particularly in vogue, an Allis's inhaler (see Fig. 201) is employed, or one of the masks, figured on p. 465, can be used; this is the semi-open method. In the completely open method a Skinner's or a Schimmelbusch's frame is used (see Fig. 205) as for chloroform. In either method the supply of ether to the evaporating surface must be continuous. It is claimed for these plans, that as there is no obstruction to the breathing, there is less lividity. The period of induction is however prolonged, the amount of ether used very large, and the atmosphere unpleasantly saturated with the vapour. Bronchitis and 'water-logging' are by no means abolished, though it is maintained by some that these may be much diminished by the prior injection of atropine (gr. $\frac{1}{100}$). It is certainly of service in children and old people and to maintain the anæsthesia induced by other means.

FIG. 201.—ALLIS'S INHALER. This consists of a mask of leather laced round a metal frame of many ribs; over these ribs is wound a long strip of flannel, domette, or some such material. The ether is poured in a small continuous stream on the flannel.

It is usual to divide the **process of anæsthetisation** into four stages, but it must be understood that this arrangement is somewhat artificial; clinically, the different stages overlap one another, and are not equally well defined in every case. These stages are:—First, the stage of confusion of ideas, with subjective sensations of dizziness, tingling of the extremities, etc. Second, the stage of excitement and more or less struggling. Third, the stage of anæsthesia, with flaccidity of the limbs, slow movements of the eyeballs from side to side, abolition of the conjunctival and other superficial reflexes; but the deeper reflexes are retained, so that there is still the power of coughing and swallowing, and, when the skin incisions are made, the muscles are apt to be thrown into spasm. The fourth stage is characterised by more markedly stertorous breathing, dilated pupils, fixation of eyeballs, and abolition of all reflexes, both superficial and deep. As a general rule, the fourth, or most profound degree of anæsthesia, is kept up only while the primary incisions are made, after which the patient may be allowed to fall back to the third degree; but in cases where considerable shock is to be anticipated, as in operations upon the abdomen, on the large joints, in the genito-urinary areas, etc., it is of great importance that the anæsthesia should be maintained fairly deeply throughout.

There are three special points in connection with ether anæsthesia which must be noted. If the vapour be introduced too rapidly, or its strength increased too suddenly, some temporary *laryngeal spasm*, with more or less coughing and straining, will very likely ensue; if this does not disappear in the course of a few respirations, air must be admitted and the proportion of vapour diminished. It is generally possible to induce anæsthesia with but little alteration in the colour; for the first four or five minutes, however, some slight *lividity* is excusable, but it is quite a mistake to suppose that persistent and marked blueness is of necessity associated with the use of ether; such a condition means either bad administration, or that the patient is not a fit subject for this particular drug. Directly the colour commences to change, air must be admitted beneath the edge of the facepiece, and if, in spite of the free admission of air, the lividity persists, or sufficiently profound anæsthesia cannot be obtained, it is wisest to change the anæsthetic. The third point is, that there is a considerable *increase in the flow of mucus and saliva*; as soon, therefore, as the muscles of the neck become sufficiently relaxed, the head must be turned to one side, so as to encourage this excessive secretion to flow into the cheek, and so out of the mouth. This is much facilitated by tucking the corner of a towel, or a tampon of lint into the cheek.

The essential characteristic of ether anæsthesia is the *stimulation*. The respirations increase in frequency and depth, and, partly on account of the presence of mucus in the air passages, they are usually noisy. The pulse becomes quicker, of greater volume, and improved in tone; an erythematous flush (ether rash) often appears over the neck, chest, and arms, and may be so well marked, and so extensive, as to be mistaken at first sight for one of the exanthemata. The pupils are widely dilated during the stage of excitement and struggling, moderately contracted during the comparatively light anæsthesia of the middle of the third stage, but tending to dilate as the narcosis becomes deeper; unless this dilatation takes place very suddenly, it is not of necessity a sign of danger, as in the case of chloroform.

The chief **dangers** in connection with the administration of ether are of an asphyxial type. The muco-salivary secretions may be so excessive that the lungs may become 'water-logged,' the heart's action seriously embarrassed, and the venous system engorged. The careful administrator ought never to allow a patient to get into this serious condition; the free admission of air, or if this fails, the substitution of another anæsthetic, should not be delayed when once the tendency is apparent. The accumulation of mucus may often be checked at the outset, by permitting the patient to come round just sufficiently to allow of his swallowing, or even, when it is permissible, vomiting. If, however, the condition of 'water-logging' has arisen, the anæsthetic must be withheld, the mouth opened, the tongue pulled forward, the mucus sponged out from the throat, vomiting encouraged, and, finally, the patient must be turned on his right side; it is in such cases as these, that the administration of oxygen is especially called for. In the earlier stages of ether narcosis, primary cardiac syncope seldom, if ever, occurs as a direct result of the inhalation, although, of course, the mere dread of the operation may have this effect; on the other hand, cases are on record in which death, occurring at a later period, appears to have been due to over-stimulation of the heart, and, perhaps, of the respiratory centre. If, then, while the patient is well under, the breathing becomes more rapid and shallower, the inhalation should be suspended for a short time until the normal condition is restored.

With the Clover's inhaler, the time occupied in producing anæsthesia must, of course, vary very considerably; from four to six minutes may be taken as a good working average. From a calculation based upon 544 cases, in which both the duration of the operation, and the quantity of ether used was noted, one ounce of ether was estimated to last, on an average, 10·4 minutes.[1]

After-effects.—If the patient has not been more than about a quarter of an hour or twenty minutes under the anæsthetic, he passes, on discontinuing the inhalation, through the stages already referred to (see p. 454), but in reverse order, viz., comparatively light anæsthesia, excitement, gradually returning consciousness. In any event, one of the first after-effects is usually the *vomiting* of mucus, often frothy and ropy, and frequently bile-stained. With ether, this is apt to be very severe during the first hour or two, but as the patient is but partly conscious, it is really less distressing to him than at first sight appears. As soon as he can do so, the patient should be encouraged to wash out his mouth with warm water, and sips of hot water should be swallowed. In some cases, especially if there has been little or no sickness, more or less violent *delirium* is observed. The frequency with which serious *pulmonary troubles* occur after the use of ether has probably been greatly exaggerated.

[1] *King's College Hospital Reports*, vols. vi. and vii.

On the other hand, there can be no doubt that the inhalation of ether renders the lungs particularly susceptible to alterations in temperature, draughts, etc. Consequently, some bronchial irritation may occasionally follow the inhalation. It is wise, therefore, to order that the temperature of the room should not be allowed to drop below 65° F., that screens should be placed round the bed, and that for the first few hours at any rate, the patient should, if possible, be kept lying on one side, by preference the right. This latter manœuvre not only assists the escape of saliva, from the mouth, but, I believe, also facilitates the onward flow of the stomach contents through the pylorus, and so diminishes the tendency to retching and sickness. Occasionally, 'water-logging,' and the effects of over-stimulation (see p. 456) do not manifest themselves until after the patient has been put back to bed, and fatal results have been recorded from these causes at this stage ; patients should, therefore, be strictly watched by a responsible person, for at least an hour or more after the completion of the operation. For a more detailed reference to after-treatment see p. 477.

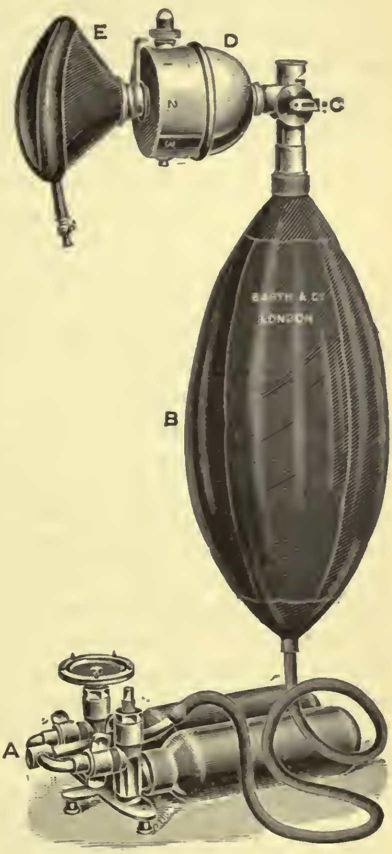


FIG. 202.—CLOVER'S PORTABLE ETHER APPARATUS, FITTED FOR NITROUS OXIDE AND ETHER COMBINED. A, Steel gas bottles ; B, Reservoir bag ; C, Three-way stop-cock connecting gas bag ; D, Ether chamber ; E, Facepiece.

NITROUS OXIDE AND ETHER COMBINED.—The so-called COMBINED METHOD is the plan of inducing anæsthesia with nitrous oxide, and maintaining the narcosis with ether (nitrogenising the ether). The procedure is as follows, viz. :—If the Clover's inhaler be used, the three-way tube and bag of the nitrous oxide apparatus are substituted for the smaller ether-bag (Fig. 202). About half a dozen full respirations of the nitrous oxide are allowed, and then the ether vapour is cautiously admitted, by rotating the ether chamber. When once the ether is tolerated, the increase in the strength of the vapour may be much greater, and made at shorter intervals than when ether alone is being administered. When irregular stertor and twitching of the muscles appear, the nitrous oxide must all be pressed out of the bag, and a breath or two of air given, or, perhaps a better plan is, to change the large for the smaller bag at this stage. It is as well to point out that a good deal of practice is required before uniformly satisfactory results are obtained. The point to be aimed at is the turning on of the ether at such a rate, that a full dose is being inhaled at the precise moment when the muscular twitching, etc., due to the nitrous oxide, are first observed.

It is claimed for the combined method that it is far more pleasant for the patient, as he is unconscious of the irritating and disagreeable taste and smell of the ether; that it is much more rapid; that to a great extent it does away with, or considerably modifies the excitement and struggling, and so enables us to dispense with the help of others in restraining the patient.

Ether is also frequently used in dental work for the purpose of intensifying the action of nitrous oxide (etherising the nitrous oxide). The Clover's apparatus may be used for this purpose, and the procedure is practically the same as already detailed, except, that the patient is allowed to get more fully under the influence of the nitrous oxide, and the ether is turned on more rapidly. I believe myself, that in this use of ether, the local effect of the vapour upon the buccal mucous membrane is largely responsible for the prolongation of the anæsthesia.

ADMINISTRATION OF CHLOROFORM.

Strictly speaking, one ought now to describe the administration of diluted chloroform in the shape of the Mixtures (A.C.E., etc.), as these rank next above ether in anæsthetic strength. To avoid repetition, however, chloroform anæsthesia will first be referred to.

Properties.—Chloroform has a chemical formula of $CHCl_3$. Its *spec. grav.* should be 1·497, and chloroform made from pure alcohol should be used in preference to the so-called methylated chloroform for anæsthetic purposes. Unless carefully protected from heat and sunlight, it is apt to decompose. It should be quite colourless; neutral to test paper; leaving no disagreeable smell or coloured residue on evaporation; giving no precipitate with a solution of nitrate of silver; and not turning brown on mixing with an equal volume of pure sulphuric acid. The vapour is upwards of four times as heavy as air, uninflammable, but decomposing into highly irritating gases when passed through or brought into contact with a flame. Hence it is important, when operating at night, or in small rooms in the presence of a naked flame, to secure a full and adequate amount of ventilation. Chloroform is one of the strongest anæsthetics that we possess; above 4 per cent. of the vapour constitutes a dangerous dose.

While with nitrous oxide or with ether, special means have to be adopted to obtain a sufficient percentage of the vapour; with chloroform, on the other hand, the greatest attention must be paid to securing a sufficient supply of air.

Cases Suitable.—If the suggestions already made (see p. 447) as to the alternative use of the several drugs be adopted, it will be found that the use of undiluted chloroform is specially indicated in such cases as the following, viz.—Infants, and very young children of one or two years of age and in people over 60; those suffering from acute or very recently acute lung trouble; in parturition, where only a partial action seems to be required; in operations about the nose and mouth, to maintain the anæsthesia induced by other anæsthetics; in proximity to the actual cautery; in cerebral cases; and most surgeons now prefer this drug alone for abdominal work. Chloroform enters largely, however, into the composition of the A.C.E. and other mixtures, so that practically it still retains a prominent place in the list of available anæsthetics.

The **preparation** of the patient should be carried out strictly on the lines suggested on p. 443, and, with regard to **position**, an emphatic protest must be entered against any attempt being made to administer chloroform to a patient sitting in a chair. This protest is necessary, because it is still occasionally used for tooth extraction with the patient in the ordinary dental position. When chloroform is inhaled the patient should be recumbent, his legs horizontal and and his body not raised above 45°.

Apparatus and Administration.—The simplest way to administer chloroform, and at the same time ensure a sufficient supply of air, is to sprinkle it *drop by drop* by means of a suitable drop-bottle (Fig. 203), on to the outside of a folded **towel** (Fig. 204), or on to a handkerchief, or, better still, on to a piece of domette stretched tightly over a metal frame (**Schimmelbusch's Inhaler**) (Fig. 205). Personally, I object to the use of lint, the woolly surface of which quickly becomes sodden, and renders the equable distribution of the vapour almost impossible.

FIG. 203.—CHLOROFORM DROP-BOTTLE WITH HOLLOW STOPPER.

By some, the **Junker's Inhaler** (Fig. 204) is preferred. The principle of this apparatus is simply that of blowing air through a layer of liquid chloroform, by means of a hand-bellows, the mixture of air and vapour being conveyed to a face-piece. Variations in the strength of the vapour are determined by the force and frequency with which the bellows are pressed. Care must be taken that the liquid chloroform does not more than half fill the bottle, and that the bellows-tube and the exit-tube are fitted to their respective metal connections. Fatal accidents have occurred from neglecting these points, as liquid chloroform is then poured into the patient's mouth.

FIG. 204. TOWEL FOLDED FOR ADMINISTRATION OF CHLOROFORM.

Whichever method be employed, it must be constantly borne in mind that **care and vigilance**, on the part of the administrator, are much more important elements of success than is the use of any particular apparatus.

Excellent results may be obtained by any plan that is systematically studied and employed.

With chloroform, as with every other anæsthetic, it is very important to **commence** the inhalation **gradually.** The evaporating surface must, at first, be held four or five inches from the face, and only brought close over the nose and mouth as consciousness is abolished and toleration established. If there be any retching, as may sometimes happen even in the earlier stages, the anæsthetic should be pressed, when the retching will often cease; but if vomiting has actually taken place, and the contents of the stomach have regurgitated into the mouth, the anæsthetic must be withdrawn, the mouth opened, and the vomited matter removed. The stage of excitement and unconscious struggling requires careful management. The condition of mental and physical turmoil is undoubtedly a dangerous one, and should not be allowed to become unduly prolonged. On the other hand, the deep inspirations which the patient sometimes takes are apt to overcharge the lungs with vapour, and so to lead to sudden respiratory and circulatory failure. The best plan, I believe, is to give the anæsthetic freely at these times, but making sure, by raising the inhaler, etc., that the amount of air is proportionately increased. It is dangerous, with chloroform especially, to bring the inhaler closer to the face while struggling is proceeding.

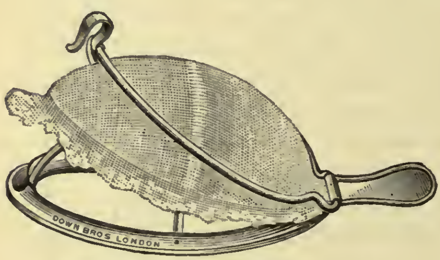


FIG. 205.—SCHIMMELBUSCH'S INHALER.

The **phenomena** observed during the induction of anæsthesia with chloroform are very similar to those already alluded to in describing ether anæsthesia (see p. 454). The stage of excitement is perhaps less marked and of shorter duration, and it is followed by a period of depression, in which the blood pressure falls, the pulse becomes smaller and weaker, and the respiration shallower. During the stage of excitement the *pupils*, as a rule, dilate rather widely, and this dilatation may continue, especially in young children and in the neurotic, for a considerable length of time, if not during the whole period of narcosis; usually, however, the pupil during the third stage is moderately contracted, *i.e.* rather smaller than with ether. During the fourth stage, the pupil tends to dilate, often suddenly, and this is an indication that the narcosis is of dangerous depth. Then, again, a rather widely dilated pupil is often the precursor of vomiting, which cannot of course occur unless the patient be but lightly anæsthetised. These alterations in the size of the pupils, when rightly interpreted, afford valuable information to the administrator, but at the same time it is obvious, that we cannot rely upon the pupil phenomena alone as indications of the exact state of the patient. Occasionally during induction, and especially in children, the patient passes imperceptibly into a curious and anomalous condition of anæsthetically induced sleep, or *false anæsthesia* ; the pupils are sharply contracted, the limbs are quite flaccid, the superficial reflexes abolished, and it is not until the deeper reflexes are excited, as by the skin incision, that we are able to recognise the fact that the state is in reality one of light anæsthesia.

The ideal condition of a patient under chloroform should be somewhat as follows, viz.: colour good, or slightly pallid ; respirations regular, fairly deep, slightly accelerated, quiet, or with a slight, soft snore ; eyeballs fixed or rotating very slowly from side to side, pupils moderately contracted and sluggishly sensitive, corneal conjunctivæ insensitive. The greatest variations from this standard will be found in the very young and the very old—in old people the respirations and

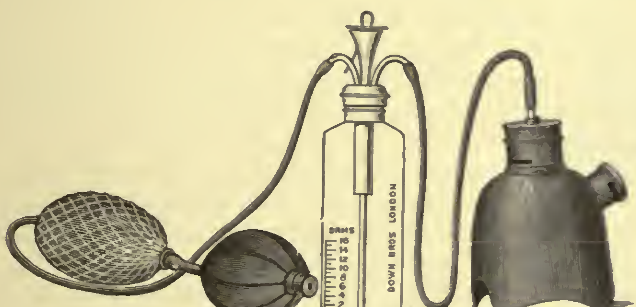


Fig. 206.—Junker's Inhaler.

pulse rate may both be very much below the average. It is impossible, however, to refer in detail to all the variations which may be observed. Very occasionally in quite young infants, an undue strength of vapour will give rise to some slight laryngeal spasm. Blueness of the lips, cheeks, ears, etc., is quite unwarranted, as it indicates that the vapour is in far too great a strength, and air must at once be supplied ; some patients become very pale under any anæsthetic which contains chloroform, and, if this pallor is gradually displaced by an ashy-grey hue, it is an indication that the circulation is failing, and the anæsthetic must be at once withdrawn, and, if need be, more energetic measures taken (see p. 473). *The respirations must be watched with the greatest possible vigilance*, and variations in the rapidity and depth should be detected early. I would lay particular stress upon the importance of maintaining the *ex*piratory phase of the respiratory cycle. Elimination of the vapour is more difficult to secure than inhalation. Quick, shallow breathing may end in total cessation of respiration, and is an indication for diminishing the strength of the vapour, or even withdrawing it for a time altogether. The treatment to be adopted when the breathing does stop will be described presently (see p. 473).

Pure chloroform, unmixed with ether, should not, theoretically, give rise to noisy or stertorous respirations, and certainly noisy breathing which cannot be rectified by slight changes in the position of the head, pushing forward the base of the tongue, by pressure upon the angles of the inferior maxilla or lifting the chin upwards, must not be allowed. There is practically no increase in the flow of mucus, etc.

The essential characteristic of chloroform anæsthesia is the *depression.* Thus, paralysis of the respiratory centre is probably the most usual cause of death in fatal cases, though cardiac failure is not unknown. This tendency to respiratory failure sets in very early, and makes it more than usually imperative that the respiration should be most carefully watched, at the same time as, but even more vigilantly than the circulation. It is probable that respiratory failure is usually associated with cardiac failure, though not always *pari passu.* As Lord Lister has pointed out,[1] the breathing may become obstructed by the falling together of the relaxed soft tissues about the air passages, and this condition has an important bearing upon the treatment, as will subsequently be explained (see p. 473).

On an average, between six and eight minutes is a fair time to allow for inducing anæsthesia with chloroform by the above method. It is said by some, that the quantity of chloroform used should be at about the rate of ʒj for every ten minutes of anæsthesia, but such estimates are unreliable, as it is obvious that the amount must vary enormously in accordance with such opposite conditions as the age of the patient, his state of health, the heat of the weather, the thickness of the towel, etc.

The special **after-effects** of chloroform differ in degree rather than in kind from those observed as a consequence of the use of ether. The vomiting may not be so severe, but it often does not set in until consciousness is more or less completely restored, and therefore the feeling of wretchedness is prolonged. Bronchitis and other lung affections are rare sequelæ to chloroform inhalation, nor is delirium at all frequent. For a more detailed account of after-treatment, see p. 477.

Dosimetric Methods.—The last few years have seen a revival of the practice of administering chloroform by means of inhalers, furnished with close fitting face-pieces and valves, with the object of regulating the strength of vapour supplied. The construction of modern inhalers is based upon the view, that anæsthesia can be **induced** and **maintained** with much smaller quantities of chloroform than was at one time thought possible ; that these small percentages are capable of accurate measurement and regulation, and that a knowledge of these percentages

[1] Holmes, *System of Surgery*, vol. iii.

added in some way to the safety of the patient; and the comfort of all concerned.

The inhaler which, at the present moment, is most in vogue, is that known as the Vernon-Harcourt Inhaler, figured and described in Fig. 207.

Considerable practice with this machine is required before its intricacies are mastered. Its best results, however, are very satisfactory, and it is said to be useful more particularly for long cases in the old and feeble, in whom, too, the tendency to shock may be still further diminished by passing a stream of oxygen through the apparatus. Those who propose to give this inhaler a trial should be warned, that the period of induction is often prolonged to ten or fifteen minutes; the indicated percentages cannot be relied upon, as they vary considerably with the temperature of the room, the angle which the chloroform bottle assumes, its steadiness, the accuracy of the various valves, and probably with the force of the respirations. As, too, the anæsthesia is very light, the patient must be watched with more than the usual vigilance in order to avoid his coming round in the middle of the operation.

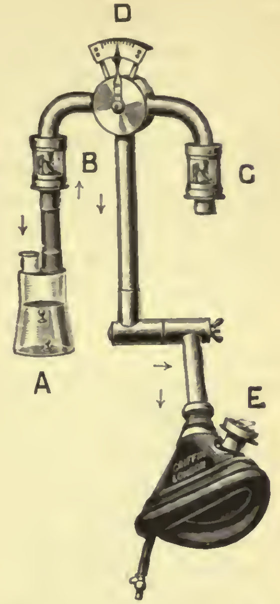


FIG. 207.—VERNON - HARCOURT INHALER. A, Chloroform bottle. B, Inspiratory valve for chloroform. C, Inspiratory valve for air. D, Regulator. The proportion of vapour varies in accordance with the proximity of the pointer to the chloroform bottle. The course of the vapour is indicated. E, facepiece and expiratory valve.

Other forms of apparatus have been devised in which known volumes of air are made to take up measured quantities of chloroform, the patient breathing the mixture out of a storage bag. These, however, are at present too cumbersome for clinical use.

ADMINISTRATION OF MIXTURES (A.C.E. ETC.).

From the point of view of anæsthetic strength, the mixtures occupy a position intermediate between ether and chloroform. Of such mixtures there may, of course, be an infinite variety, according to the relative proportion of the constituents, but to certain stock mixtures definite names have been attached; thus, a combination of one part of chloroform to three of ether is known as the **'Vienna mixture,'** while **'Billroth's mixture'** consists of three parts of chloroform, one of ether, and one of absolute alcohol. In this country, however, **'the A.C.E. mixture,'** or, as it is often called, 'the mixture,' is the term by which is usually indicated a fluid composed of absolute alcohol *spec. grav.* 0·795 one part by volume, chloroform *spec. grav.* 1·497 two parts, and ether *spec. grav.* 0·720 three parts; it is usually looked upon as merely a mechanical mixture of its constituents.

Properties.—Its *spec. grav.*, when freshly prepared, is as nearly as possible the mean of its three constituents, *i.e.*, 1·0; the *spec. grav.* of its vapour has not been experimentally determined. The particular purpose served by the alcohol is not very clear; possibly the advantage is mainly mechanical, leading to a more intimate admixture of the several constituents, but it is also claimed that the evaporation of the ether is somewhat retarded. It is said to be somewhat unstable, and it is always recommended that it should be freshly prepared, as required. Of late years I have been in the habit of employing a mixture of one part of chloroform and two of ether, *i.e.* the same relative amount of chloroform, rather more ether and no alcohol. An advantage of this combination is that its constituents are more likely to be at hand when a fresh supply is wanted. I usually mix it in the operating room for each case.

Advantages.—The question is often asked, why the mixture should be preferred to pure chloroform. The reply to this query is founded partly upon theoretical, partly upon practical considerations. Theoretically, I am inclined to believe that the stimulating effects of the ether vapour, however slight, cannot but be of service, and that, by using a moderately diluted vapour, there is much less risk of overstepping the narrow margin of safety which is so characteristic of chloroform anæsthesia. Practically, I am sure that, with the mixture, one obtains earlier notice of impending danger than with chloroform alone. Neither the mixture nor any of the anæsthetics at present known are absolutely safe, but the danger with the A.C.E. is chiefly that of over-narcosis pure and simple, and of this more ample warning is given than with chloroform; to a great extent, though perhaps not entirely, the element of sudden over-dilatation of the heart is eliminated.

Cases Suitable.—When neither nitrous oxide nor ether are advisable, the next anæsthetic to be considered is a mixture. The list of objections to the use of ether, therefore, given on p. 452, constitutes a list from which cases suitable for the use of mixture can be selected. But even the small amount of ether contained in the mixture may be considered harmful in those actually suffering from extensive lung disease; when the actual cautery is to be employed in close proximity to the inhaler; and as an inhaler is usually employed, it is not easy to maintain the narcosis with mixtures in operations about the mouth and nose.

The **preparation** of the patient should be carried out on the lines suggested on p. 443, and no **position** is permissible but the recumbent, or one on which the legs are, at least, on the level of the body.

Apparatus and Administration.—No form of closed or bag-inhaler should be used for A.C.E. or other chloroform mixture. In very small children, and in neurotic adults, it may be given by the open method, *i.e.*

by dropping on an open mask (p. 460) or on a handkerchief held just above the mouth. Generally speaking, however, an inhaler is desirable; a useful form is the metal mask depicted below (Fig. 208). This apparatus is made of metal, and can be purified in lotions or by heat. The sponge is retained in position by means of a wire guard Fig. 209 (B) and a shield set at an angle (A) prevents the liquid from running on to the face. The hinged, perforated, concave top (D) is convenient for charging without removing from the face. It is important that a very free supply of air should be available, so the ventilation holes must be large (¼ in.) and numerous, and the facepiece ought not to fit over the nose and mouth with any great accuracy, and for this reason a padded facepiece is objectionable. Anæsthesia may be *maintained* or even induced with ether in these masks, if necessary.

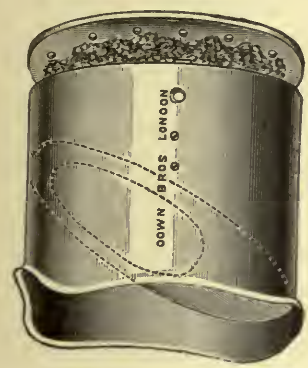


Fig. 208.—Metal Inhaler for Mixtures.

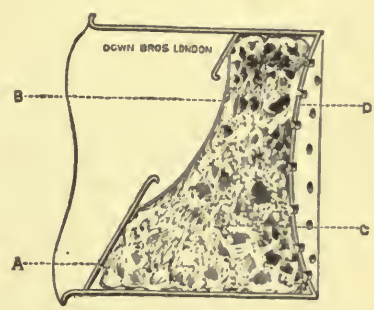


Fig. 209.—Metal Inhaler, in Section. A, Shield; B, Wire guard; C, Sponge; D, Perforated top.

In the actual administration two points are to be particularly attended to, viz.: Use small quantities of the mixture frequently repeated, rather than one or two large doses. By this means, the stimulating effects of the ether are more nearly continuous than when a large quantity of the liquid is used at a time. Secondly, in this, as in all other methods of inducing general anæsthesia, it is important to commence the inhalation very gradually, holding the facepiece a few inches from the face to begin with, and gradually bringing it nearer as the vapour is better tolerated.

The chief **objections** which have been urged against the use of the mixture are as follows, viz.: it is sometimes said that an over-strong vapour, consisting chiefly of chloroform, is apt to accumulate in the mask below the sponge. The possibility of this occurring cannot be doubted, and the remedy is equally obvious. The mask must not fit the face at all closely, and must be supplied with plenty of large air-holes, and the anæsthetic must be added in small quantities (ʒj—ʒij) at a time. Under this head, too, must be included the objection, that the different constituents of the mixture evaporate at different temperatures. This, of course, is true, but experience has shown that the consequent slight variations in the composition of the vapour, do not militate against the practical efficacy of the mixture.

Bearing in mind that the most potent constituent of the A.C.E., and most other mixtures, is the chloroform, it is only natural that the **phenomena** observed, and the precautions to be adopted in their administration, are but modifications of those already described under the head of the latter drug. Owing to the stimulating effect of the ether—which should be almost continuous, if small, frequently repeated doses, mixed with plenty of air, be given—the depressing effects of the chloroform are less apparent. On the other hand, laryngeal spasm is of slightly more frequent occurrence in children, and as the flow of mucus is increased, the breathing is apt to be a little more noisy. The ether-rash (see p. 455) is occasionally observed, and the pupils are, on the whole, inclined to be rather more widely dilated than with chloroform in the third stage of anæsthesia.

The dangers and after-effects are essentially those of chloroform (see p. 471), but as they are rather more gradual in their onset, they can usually be detected before the condition of the patient becomes serious. There appears to be less fear of early cardiac syncope.

In cases lasting more than about three-quarters of an hour, I often increase the proportion of ether in the mixture by gradual additions of that drug.

About 1½ ounce should suffice to induce anæsthesia; in children less will be required. Five to seven minutes should be allowed for the production of the primary narcosis. From a calculation based upon 2801 cases, in which both the duration of the operation and the amount of mixture used was noted, one ounce of A.C.E. was estimated to last on an average 15·6 minutes (*King's Coll. Hosp. Rep.*, vols. vi., vii. and viii.).

ETHYL CHLORIDE (C_2H_5Cl) is a colourless liquid with a somewhat pungent, but not disagreeable odour. It evaporates at a temperature of 12·5° C. (52·5° F.), and the vapour is very inflammable. It forms the basis of many of the proprietary

FIG. 210.—CHLORIDE OF ETHYL TUBE.

articles used for the production of anæsthesia by freezing, such as Anestile, Kelene, Narcotile, etc., and it is the chief contsituent of 'Somnœform.'

It is usually sold in glass tubes containing about 50 c.c., fitted with a spring stopper (Fig. 210). When the minute hole in the nozzle is uncovered, the heat of the hand suffices to drive out a capillary stream of the liquid, which may either be used for freezing or directed into a proper receptacle for inhalation. It is also sent out in hermetically sealed capsules of 3 or 5 c.c., which may be broken as required.

When employed by itself for inhalation, 3–5 c.c. are dropped into a bag or other form of closed inhaler. Its action is very rapid and complete, but as some fatalities have attended its use it has lately fallen into disrepute. I believe myself that these accidents are largely due to faulty methods of administration; such a powerful drug ought not to be administered in a closed inhaler or bag. For some years I have used it almost invariably as a preliminary to the introduction of the mixture, and have had practically no trouble with it. My plan is to spray from 8 to 10 c.c. on the sponge of a mask (Fig. 208) from below, apply it the face, and directly the breathing becomes slightly stertorous, or there are any other indications of loss of consciousness, pour a full dose (℥j—℥jss) of the A.C.E. or similar mixture on the sponge, from above. The chief advantage of this method is the rapidity with which consciousness is abolished; I think, too, that the stage of excitement is always curtailed, and often disappears completely.

ADMINISTRATION IN SPECIAL CASES.

Under certain conditions, some slight departure from the ordinary routine methods of administration seems to be desirable, but space will not permit of more than a passing reference to these cases, and this reference may most conveniently take the form of indicating my own practice in the matter.

In intra-cranial operations, anæsthesia is induced in the recumbent position, and the body is raised slowly and cautiously to an angle of about 45°. Chloroform or a mixture is used throughout, and only just enough anæsthetic is given to keep the patient quiet. His disease renders him very susceptible to an over-dose, and at the same time makes him less susceptible to actual pain.

Operations about the Nose and Mouth.—In such short operations upon the nasal passages as the removal of turbinated bodies, etc., the operator often considers it better for the patient to be sitting up, in which case, of course, nitrous oxide, with or without the addition of oxygen or ether, is the best anæsthetic, and as soon as possible the body should be pushed well forward, so that the head may hang over a basin placed between the knees, when the blood will run out of the nose and mouth. A somewhat similar position and procedure will, in the opinion of some surgeons, suffice for the removal of tonsils or adenoids, but when the choice is left to the anæsthetist, I must confess that I have a preference for the plan of lightly anæsthetising the patient in the recumbent position with Mixture, and turning him on the right side as the operation proceeds.

Use of Junker's Inhaler with Tube.—In long operations about the buccal cavity, *e.g.*, removal of the tongue, I prefer to induce anæsthesia to a tolerably profound degree with Mixture, and to maintain it with chloroform given out of a Junker's inhaler (Fig. 206) in which the face-piece has been removed and a tube substituted. The tube (Fig. 211) should have an internal diameter of, at least, four millimetres (they are generally much too narrow), and may be passed down the nose if necessary. Some administrators prefer to very thoroughly saturate the patient with ether for five or six minutes before the operation is commenced, and then, if need be, continue with chloroform. My own experience is that ether causes undue congestion and bleeding, and the increased flow of mucus still further obscures the field of operation, and increases the tendency to asphyxia. In the more delicate operations in this region, *e.g.* sub-mucous resections of the septum-nasi, chloroform should be used from the beginning. The practice of different surgeons varies considerably in respect to the **position** adopted for the performance of these operations. Many surgeons prefer that, whenever possible, the patient should be absolutely recumbent, the head being allowed to hang over the end of the table, with the neck extended, so as to bring the post-nasal space into a dependent position. Personally, I am doubtful whether much is really gained by this, and I am quite sure that the bleeding is more profuse, and that the stretching of the muscles and tissues of the neck causes much after-discomfort. Others, again, like to have the head and shoulders well raised, and perhaps the chin strongly flexed towards the sternum. There are still others who place the patient sitting almost bolt upright; this position is not, perhaps, without some risk, and is not an ideal one for the anæsthetist, but I must admit that after much experience I have never seen trouble arise from its adoption. It is essential, however, that the feet and legs should be well elevated, and the body arranged for rapid lowering should signs of syncope present.

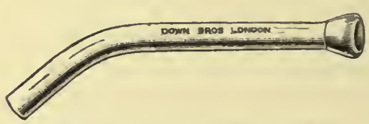


Fig. 211.—Mouth Tube of Stout Metal. At least 4 mm. in calibre.

In such delicate operations as those for cleft palate, the dorsal position, with the head more or less extended, is imperative, so as to obtain the best view possible of the parts. In these cases, too, some surgeons of great experience consider that healing is retarded by the direct impact of the chloroform vapour from the tube upon the freshly cut edges of the wound, and they prefer to maintain the anæsthesia by means of chloroform dropped upon a towel or lint; but direct impact of the vapour ought to be easily avoided, and when this is done it is difficult to understand why, if the patient be kept well under, the use of the towel or lint should be less injurious.

In using the Junker's apparatus where the breathing is likely to be obstructed, it is important to bear in mind that the heavy vapour of chloroform is apt to accumulate at the back of the throat, directly the breathing becomes in the slightest degree obstructed, so that the energy with which the bellows should be worked must be directly proportionate to the freedom of respiration.

In extensive operations upon the base of the tongue, etc., when **preliminary tracheotomy** is advisable, a Hahn's or Trendelenburg's tampon is sometimes inserted (Fig. 212), the anæsthesia being then maintained through the tracheal opening. By some surgeons laryngotomy is preferred in these cases. No tampon is used, and the anæsthetic is administered through the tube by means of a Junker's inhaler and tube attachment.

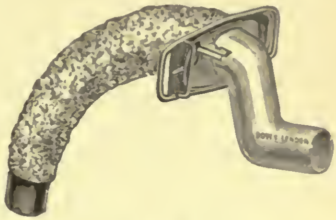


FIG. 212.—HAHN'S TRACHEOTOMY TAMPON.

Patients with **enlarged thyroids** are very liable to sudden attacks of syncope while taking anæsthetics, but, on the other hand, it is really remarkable what a very small quantity of anæsthetic will suffice to keep such patients thoroughly under. In thyroidectomies, therefore, I frequently use a Junker's apparatus throughout, giving but very little of the anæsthetic, only just enough to restrain the retching and vomiting to which such patients appear to be particularly prone. Abroad,

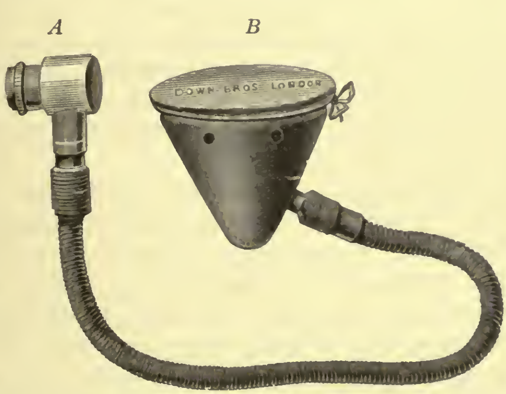
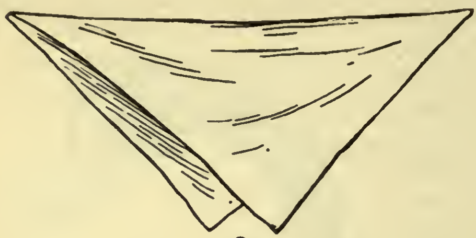
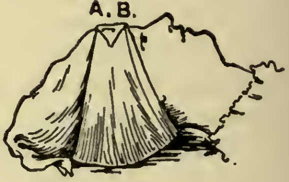


FIG. 213.—HAHN'S CHLOROFORM ATTACHMENT. *A*, Junction with tracheal tube. *B*, Metal cone covered with domette on which the chloroform is dropped.

local anæsthesia in the shape of cocaine is largely employed in these operations, but it appears to be quite possible that the success of this drug in these cases is, in some measure, due to the difference in the type of the patients, as compared with those seen in this country.

In all these operations about the head and neck, some trouble is experienced in preventing the hair from falling into the wound, and in keeping the blood from the hair. I have adopted the device shown and explained in Figs. 214 and 215.





Figs. 214 and 215.—Protection of Hair in Operations in that Region. A carbolised towel is folded cornerwise; the middle of this folded edge is placed over the forehead, the ends A and B crossed well behind the occiput, and brought up to the forehead and secured by a pin. The end C may be utilised for securing stray strands of hair. The appearance will be as in the right-hand figure.

In **abdominal operations** many surgeons prefer the use of chloroform on the grounds that the anæsthesia is quieter, the muscular relaxation more perfect, and the after-sickness, if any, is less violent. If ether be used for these cases the increased flow of mucus, associated with the temporary paralysis of the abdominal muscles, increases the risk of bronchial and pulmonary complications. When the stomach is to be opened it may be washed out with a stomach tube, but this should be done not less than half an hour beforehand; it is of no advantage, but rather the reverse, to do this at the last moment, or when the patient is actually anæsthetised. In cases of fæcal vomiting from intestinal obstruction, the contents of the stomach may be siphoned off just before the operation.

In **severe operations** in robust adults in which much shock is to be anticipated, it is of importance that the anæsthesia should be tolerably profound throughout. Among such operations I would particularly enumerate those affecting the big joints, those involving manipulation of the spermatic cord, operations upon the genito-urinary and rectal areas, and abdominal operations. When patients are losing much blood, or are suffering from primary shock or much prostration, the strength of the vapour inhaled may be considerably diminished. It is in such cases that nutrient enemata and strychnine hypodermically are useful, and in which a regulating inhaler is of advantage.

Alcoholics are troublesome subjects to anæsthetise. They are apt to struggle very violently, to become very livid, and unless reduced to a dangerous degree of narcosis, they are often very restless. This is especially the case when ether is used. Their tissues are often much degenerated, so that in choosing an anæsthetic for such patients it must be remembered that they are prematurely aged. Acute or far advanced cases should perhaps be started with Mixture, and ether gradually added.

In this connection reference must be made to the condition known as the **status lymphaticus.** By this is meant an enlargement of the thymus gland and a general hypertrophy of the lymphatic tissues throughout the body. The condition is an undoubted pathological fact, and as such has been held to be sufficient to account for otherwise inexplicable cases of sudden death, whether occurring on the operating table or in the street. Persons suffering from it (mostly children) are said to be particularly susceptible to chloroform. It unfortunately happens, however, that the clinical signs and symptoms of the disease are so very indefinite, that it is rarely recognised during life, and it is more than probable that a large number of children, afflicted in this way, pass through the ordeal of an operation without causing the slightest anxiety to the anæsthetist. The possibility of the existence of the condition, however, is another argument in favour of the view that children are, if anything, more, rather than less, susceptible to chloroform than adults, and that correspondingly greater care should be taken with them.

DIFFICULTIES AND DANGERS.

Difficulties and dangers directly connected with the anæsthetic are due to the effects of the various drugs upon either the respiratory or the circulatory systems. Many and bitter are the controversies which have arisen as to which system is primarily affected, but much of this discussion has been of an academic rather than of a practical character ; at present, the balance of opinion appears to be in favour of ascribing to both functions some share in the production of fatal results. At any rate, it is admitted, on all hands, that the depression in the respiration, even if it is not absolutely coincident with the circulatory failure, precedes or follows it so closely that, clinically, it is almost impossible to distinguish between the two effects, and, therefore, the line of treatment must be such as will give relief in both directions.

Simple **syncope** appears to be an accident to which patients are occasionally liable in the very earliest stages of the inhalation. Some such cases are undoubtedly due to mere fright, and can hardly be ascribed to the toxic effects of the anæsthetic ; but, on the other hand, many cases are on record in which no such dread of the operation existed, but where, nevertheless, the patient, often a strong healthy adult, has suddenly succumbed after inhaling the anæsthetic for a few minutes, when apparently unconscious, and passing into the third stage (see p. 454). The existence of a condition of status lymphaticus has been put forward in explanation of some of these cases.

In origin, **respiratory troubles** may be spasmodic, asphyxial, or due to the toxic effects of the drug upon the central nervous system. **Spasm of the glottis** may occur with any anæsthetic, but especially with ether when the vapour is too suddenly applied, or increased in strength too rapidly ; the treatment is obvious, namely, withdrawal or diminution in strength of the vapour and no further reference need be made to it here. The irritation of the ether vapour may sometimes cause a good deal of coughing, and if this does not subside in the course of a few minutes, the inhalation of a few drops (10–20) of chloroform will often have a good effect, and the ether inhaler can subsequently be re-applied. **Asphyxial symptoms** are usually associated with marked lividity and gasping for breath, and may be due to a variety of causes, such as the presence of foreign bodies (false teeth, detached nasal polypi, etc.), to excessive flow of mucus, to blood, to extraneous pressure upon the trachea, to falling back of the tongue over the glottis (sometimes termed 'swallowing the tongue'), etc. Under this head, too, may be included those cases described by Lord Lister, in which the soft structures at the back of the throat fall together like curtains in front of the glottis.

Respiratory Paralysis.—Of course, under any of the above circumstances, the breathing tends to fail ; but when we speak of 'failure of breathing' under anæsthetics, and especially chloroform, what is usually meant is the failure due to an overdose. The nervous system becoming paralysed, the medullary centres cease to act, and the respiratory movements, becoming feebler and feebler, at length stop altogether. The ashy-grey pallor and imperceptible pulse, the entire cessation of breathing, the complete relaxation of the tissues (extending sometimes even to the sphincters), the widely dilated pupils, the general aspect of the patient, not unlike the *facies hippocratica* of actual death, are all very characteristic, and, in fact, may almost be said to be pathognomonic of chloroform poisoning ; sometimes, the respiratory failure is almost lightning-like in rapidity, but more often it is gradual and insidious in onset.

As is well known, the clinical signs and symptoms of respiratory paralysis closely resemble, and are frequently associated and coincident with those due to syncope, and, on the other hand, obstruction to the breathing sooner or later leads to cardiac failure. In practice, it is often impossible to decide whether the respiratory or the cardio-vascular system was first affected, but it is of the utmost importance that the administrator should be able to appreciate the fact, that certain signs and symptoms are indicative of approaching danger from their very commencement. Such early recognition of symptoms is only possible when the administrator is unceasingly vigilant, and single-minded in his attention to his duties, and when thus recognised the mere withdrawal of the anæsthetic often suffices to correct the error, without subjecting the patient to any additional risk.

It is to the respiratory and the circulatory systems, and especially the former, that the greatest attention should be devoted, and the slightest alteration in either one or the other should be carefully noted and watched.

If this be done, it will soon be seen that **signs of danger** may very readily be grouped under three heads, namely:—

(1) Symptoms in which cardiac failure or syncope is the prominent feature. (Pallor, pulse gradually becoming imperceptible; pupil slowly dilating; respirations unaltered at first, but gradually failing, though seldom abolished completely.) Generally to be looked for in the earlier stages of anæsthesia; often the precursor sickness. As a rule, easily recoverable.

(2) Symptoms in which the respiratory failure is the most prominent feature. (Respirations early affected, feeble, and shallow; pallor, often of the ashy-grey type; pulse fairly good at first, but slowly failing; pupils quickly dilating.) A condition of the middle and late stages, and tending to merge into

(3) Simultaneous or almost simultaneous, sudden, and complete cessation of both circulation and respiration, with *facies hippocratica*, suddenly and widely dilated pupils. May occur early (syncope) or late (toxic overdose). A very serious condition; when fully developed in the earlier stages of anæsthesia, it is doubtful if recovery be possible.

Treatment.—Reference has already been made (see p. 456) to the treatment to be adopted when, in ether anæsthesia, the muco-salivary secretion becomes excessive, and to the treatment of spasm of the glottis. The treatment of other forms of gross asphyxia is so perfectly obvious, that it may be dismissed in a very few words. If, with a patient sitting up, as for nitrous oxide anæsthesia, blood or a foreign body, such as a tooth, slips back into the larynx, the body of the patient should be bent sharply forward so as to bring the head over the knees; coughing should be encouraged by smartly patting the back, and by passing the finger into the throat to irritate the vocal cords. This latter manœuvre may reveal the presence of the foreign body itself, and an attempt may be made to remove it by means of the laryngeal forceps; if this attempt do not succeed, the advisability of performing tracheotomy, or even better, laryngotomy, must be considered. Of course, in many cases, this operation would be performed by the operating surgeon, but the administrator should always be provided with suitable instruments, for occasion may arise, *e.g.* in dental work, in which they may be urgently called for and when the anæsthetist may himself have to operate. In any event, the responsibility rests with the anæsthetist.

In respect to the other symptoms mentioned above, it must be borne in mind that, although in some instances their development is almost unavoidable, yet in many if not in the majority of the cases in which they are very pronounced, they can be traced to some error of omission or commission on the part of the anæsthetist. It may not, therefore, be out of place to recapitulate what may be termed the **prophylactic treatment** in respect to these symptoms, viz.—

(*a*) Take care to remove beforehand anything that may obstruct the breathing, or that may fall into the throat when the parts are relaxed under anæsthesia.

(*b*) Excepting in the case of nitrous oxide, always induce anæsthesia gradually ; this does not of necessity mean slowly, but rather the graduation of strength of the vapour, not increasing the strength beyond that which can be readily borne.

(*c*) The administrator should devote the whole of his attention to the administration. He should not be called upon to hold instruments, or otherwise assist the surgeon, or even interest himself about the operation.

(*d*) As soon as sufficiently relaxed, the head must be turned to one side, so as to permit the mucus to flow out of the mouth and prevent the tongue falling backwards.

(*e*) The respiration and especially the *ex*piration must be watched with particular care, the hand being occasionally held in front of the nose and mouth to test the force of the breathing. The movements of the chest and abdomen are not to be relied upon, as they may be altogether out of proportion to the amount of air actually entering the lungs. Nor is the sound of the breathing to be depended upon ; it may be largely due to mucus, or to buccal or palatine stertor. In my opinion, too, mechanical indicators in the shape of feathers, etc., are apt to be fallacious. They induce a false sense of security, as they do not distinguish between a very light and a moderately forcible expiration. At the same time the circulation, as indicated by the colour of the face and ears, should be watched, and the pupil observed.

(*f*) If in doubt as to the exact significance of any particular or peculiar symptom or change, it is safer to allow the patient to come round rather than press the anæsthetic.

Active Treatment.—If, however, any of the conditions indicated above have developed, the following routine treatment should be adopted. It is of importance that the exact order of procedure be observed ; that each step be carried out deliberately and completely without flurry ; that a wait of at least a few seconds be made between each movement, to be sure of its effect, and, in extreme cases, that treatment be persevered in for some time, even although apparently hopeless.

(1) Keep the head turned to one side, but do not otherwise alter the position of the patient. Withdraw the anæsthetic. Extend the head upon the trunk by pressing backwards upon the forehead ; release the base of the tongue by forcible pressure upon the lower law at the angles, so as to protrude the lower incisor teeth beyond the upper, or by pulling forward the chin so as to **raise the hyoid bone and larynx.** It will often happen that in the very earliest stages of respiratory embarrassment,

nothing more is required. If the breathing be not restored by these means the next step is—

(2) Open the mouth, by means of the gag which should always be at hand (Fig. 216), if necessary, seize the tip of the tongue in the forceps (Fig. 217), and **pull the tongue forcibly forwards.** This does not move forward the base of the tongue to any appreciable extent, but mainly acts reflexly, and causes the retraction of the soft tissues in front of the glottis, and is, therefore, of particular service in the condition described by Lord Lister (see p. 462).

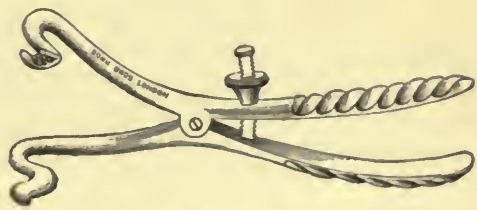


Fig. 216.—Mouth Gag.

(3) Should the above manœuvres have no effect, the next proceeding is to explore and **clear out the air-way.** The finger is passed to the back of the throat, and used as a hook to draw forward the epiglottis and base of the tongue, and this has often a very marked effect, and should on no account be neglected. At the same time, anything in the shape of a foreign body can be felt for, and, if found, attempts may be made to remove it with the finger, or by means of the laryngeal forceps. The throat must be sponged to get rid of the mucus and blood, and, if this be excessive, the patient may very gently be turned on one side.

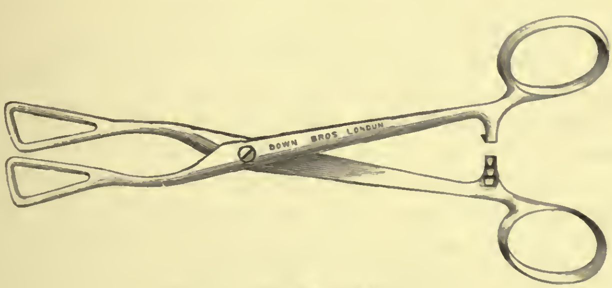


Fig. 217.—Tongue Forceps.

If a foreign body or definite obstruction can be felt, but cannot be removed with the finger or by means of the forceps, and if the asphyxia is becoming more intense, the question of tracheotomy may now arise but mere feeble breathing, without definite signs of obstruction, is no indication for opening the trachea.

It is absolutely essential to commence with the above three proceedings as preliminary to anything else that may be done ; it is useless to attempt to force air into the chest, by artificial respiration or other means, unless we first assure ourselves that the air-passages are clear. Violent movement of the patient at this early stage may have no other result than that of shaking the last flicker of life out of his body; do not, therefore, be over-hasty. If, after waiting for ten or fifteen seconds, we get no response to our efforts, the next steps are—

(4) Make two or three **momentary pressures upon the sternum**; it may be that it is merely the rhythm of respiration which is in abeyance.

(5) **Invert the patient.** Children may be held up by the heels; with adults, an assistant standing on the table may hold up the legs, and the body of the patient may be pulled upwards, so that the head hangs over the end of the bed. One theory explaining the action of this proceeding is, that it empties the blood from the abdominal viscera towards the heart and brain. The effect, therefore, is one of mechanical stimulus, and, if this be so, one can understand the advice which is given not to prolong the position for more than a few minutes at a time.

(6) In adults, even while inversion is being tried, **artificial respiration** may be started, commencing slowly and gradually. The well-known Sylvester's method is the one usually adopted. Standing at the patient's head, a firm grasp is taken just below the elbows, and the arms brought outwards and upwards with a rotatory movement, some force being used to cause the forearms to cross above the head; expiration is brought about by reversing the movement, pressing the arms firmly against the chest walls so that the forearms cross over the front of the chest. In Howard's method, which is a most valuable adjunct to the above, the surgeon kneels astride of the patient, places his outspread palms over the margins of the ribs, pushes up the abdominal viscera against the diaphragm, and then allows them to fall away, and so alternately diminishes and increases the capacity of the thorax. When possible, these two methods should be carried out simultaneously, but in any event the movements should not be made roughly or too rapidly; about sixteen or seventeen to the minute is ample. In infants, it is useful to remember that pressure on the abdomen upwards towards the diaphragm, or upon the costo-diaphragmatic margin, is often more effectual than anything else.

It has been urged against these two plans of artificial respiration that there is a danger of pumping up the contents of the stomach into the pharynx, and so practically drowning the patient, and the Marshall Hall method of turning the patient alternately upon his face and side has been suggested as an alternative. But the objection can hardly apply unless the movements have been made altogether too violently and too quickly, and mention is only made of it here in order to emphasise these points, and to put the administrator on his guard.

In the majority of cases, if the breathing has shown no signs of recommencement after artificial respiration has been continued for five or ten minutes, the prognosis is exceedingly grave; but it is not altogether hopeless, so that, while still persevering with the artificial respirations, some of the following plans should be adopted by the assistants. It must be quite understood, however, that although these plans are to be carried out concurrently with the artificial respiration, and on no account is the latter to be superseded by them.

(7) **Cold affusions** in the shape of douches or flipping the chest with wet towels. Alternate very hot and cold sponges to the perineum.

(8) **Inhalation of nitrate of amyl** to alter the distribution of the intra-vascular tension. Strong ammonia held to the nose.

(9) **Electricity.** Either the interrupted (Faradic) or the continuous current may be used. One pole is applied to some neutral point, *e.g.* the nape of the neck, and the other pole is pressed over the cardiac area, along the costo-diaphragmatic margin, or along the course of the phrenic and pneumogastric nerves in the neck, the current being alternately made and broken.

(10) **Hypodermic injections of ether** or brandy (♏xxx) are usually given, but the proceeding is a little illogical. The patient is already suffering from a form of alcoholic poisoning, and, further, the circulation is too depressed to hope for absorption. For this latter reason, too, the hypodermic injection of drugs, such as digitaline, is hopeless at this stage.

(11) The **intra-venous injection of normal salt solution,** or rectal injections of the same, appear to be more rational. By altering the blood pressure they may possibly stimulate the circulation.

(12) As almost a last resource, **acu-puncture or galvano-puncture of the heart** itself has been recommended. It has even been suggested that by making a small incision along the margins of the left ribs, the fingers of the hand can be passed in, and direct pressure applied to the heart. I have no personal experience of these measures, but it appears to me that acu-puncture and galvano-puncture not only waste valuable time, but are more likely to do harm than good. The plan of directly pressing on the heart seems to be better justified, theoretically, but it has not been very successful in the few cases in which it has been put to practical proof.

Supposing that no response has been obtained to these efforts, the artificial respiration should be persevered in for at least half an hour, and of course, if the slightest attempt at natural breathing be made, a longer time should be given to the work. Even after a fairly regular, though feeble respiratory rhythm has been re-established, the greatest care should be taken in moving the patient, as relapses are apt to occur ; he should not be left for some hours, and should be kept very warm.

AFTER-TREATMENT.

In conclusion, a few words may be said as to the after-treatment of patients recovering from an anæsthetic, as this is a point upon which the anæsthetist is often consulted. Practically, no after-treatment is required for nitrous oxide; the following remarks are intended only for the major anæsthetics.

In dressing a case after operation, care should be exercised that the bandages, etc., do not impede the breathing. This is particularly necessary in operations about the head and neck, and it comes within the province of the administrator to see that no trouble arises from this cause. In these cases the bandages should be firmly applied, while the neck is fully extended; the pressure will not then be too great when the neck is restored to position.

In ordinary cases, the patient may be put back to a warm bed before he completely recovers consciousness. In making the transfer, however, care should be taken not to jolt him, and especially not to elevate the head and chest; in going upstairs, therefore, he should be carried on a stretcher, feet first, with his head down. The room should be of a temperature of about 65°–70° F., and the bed carefully screened from draughts. If ether has been employed, and perhaps in all cases, it is better, if the surgeon will permit, that the patient be turned upon the right side; this facilitates the escape of mucus, and I think lessens the sickness. The nurse should be warned that if sickness occur, the patient is not to sit up, but to be turned on his side, and, if need be, the jaw must be pushed forward to facilitate the escape of the vomited matter.

The anæsthetist should assure himself that his patient is on the high road to recovery before he leaves the patient's side, but on the other hand, natural sleep is to be encouraged; if, when taken at intervals of two or three minutes, the pulse and respiration are found to be good and improving, it may fairly be assumed that, as far as the anæsthetic is concerned, the patient is safe. In any event, whether the case is a severe one or not, the patient should always have a responsible attendant at his bedside for an hour or two after the operation has been completed.

Sickness.—As soon as he is sufficiently conscious to be able to do so, the patient should be encouraged to rinse out his mouth and throat frequently with warm water. If retching and vomiting occur early, in the semi-unconscious condition, they are less distressing to the patient than might be supposed; when he becomes fully conscious he seldom retains any recollection of his previous misery. Nevertheless, attempts should be made to ameliorate his condition. Sips of water as hot as can be borne, or even full draughts of half a tumblerful, are often successful; strong, hot, black coffee is good in some cases; 15–20 grains of bicarbonate of soda in a tumblerful of hot water is good in others; ice to suck is the routine treatment, and is very comforting to the patient; strychnine in 5-minim doses of the *liquor* by the mouth or hypodermically, has been recommended; bromide of potassium 20 grains and chloral hydrate 15 grains dissolved in 2 ounces of water and passed into the rectum immediately after the operation is said to act very well in some cases;

in the more troublesome cases morphine may be called for, but in the majority of instances time alone is all that can be depended upon.

Cases involving severe '**surgical shock**' require additional care. In such cases, the amount of the anæsthetic used in the latter stages may, with advantage, be very much diminished, and strychnine hypodermically may be given freely up to $\frac{1}{15}$ grain. It is in these cases, too, that the hypodermic injection of brandy or ether may be of value, but enemata of hot black coffee or beef-tea are probably better. Such patients should not be put back to bed too soon, but be kept on the operating table, which should be raised some four or five inches from the ground at one end so as to raise the patient's legs. Anæsthetised patients are so very apt to be blistered by hot water bottles that I now make it an absolute rule, never to permit one to be placed in the bed, until after the lapse of twenty-four hours. If additional warmth be required, hot blankets should be used.

If the shock be the result of loss of blood it may be advisable to give an injection of normal salt solution into the veins, the cellular tissue of the axilla or the rectum (see p. 112); the hot nutrient enemata recommended above is also very efficacious.

The patient may recover perfectly from the immediate effects of the anæsthetic, but it occasionally happens that, about twenty-four hours after, his temperature rises and his pulse becomes feeble and quick; there is great restlessness and some delirium, and the patient dies comatose. At the post-mortem the liver is found to be enlarged and to present every indication, microscopically, of acute fatty degeneration. These fatalities are most frequent in children, and after chloroform, but they are also seen in young adults, and after other anæsthetics; and the condition known as status lymphaticus acts as a predisposing cause. The treatment of these cases is unsatisfactory; stimulants and cardiac tonic such as strychnine, digitaline, etc., are indicated, but when once the coma has set in, recovery is rare; in this as in other respects they somewhat resemble cases of diabetic coma.

The train of symptoms described above has been the subject of careful inquiry by Stiles and MacDonald. These investigators suggest that the symptoms are due to the toxic action of the anæsthetic rather than to septic infection, as was at one time supposed, and as the microscopic appearances might lead one to suspect. In accordance with these recent views, the condition is now known as that of 'delayed chloroform poisoning,' and the responsibility for the death is shifted from the operation to the anæsthetic. I must confess that I have practically no experience of these cases.

Diet.—No food should be given by the mouth for at least three or four hours after an anæsthetic has been administered (in the case of nitrous oxide, however, an hour's abstinence will suffice), and a further wait of two or three hours should be made, unless the patient express a desire for food, or if the sickness be very persistent. In cases of collapse, marked emaciation and feebleness, etc., nutrient enemata should be given every two or three hours, commencing immediately before the operation, rather than run any risk of irritating the stomach. The first food by the mouth should take the form of broth, beef-tea, or soup, in preference to milk, which is apt to form a hard indigestible curd which may irritate the stomach in its catarrhal condition. When the first food has been retained, the patient may return by degrees to the ordinary diet, as far at any rate as the anæsthetic is concerned.

Delirium and excitement, when they occur, must be gently restrained, but the patient must not be tied down. In the case of lunatics, the feeble-minded, and even those with a previous history of mental disturbance, the friends should be warned that a recrudescence of the mental trouble occasionally occurs after the administration of any anæsthetic.

PART II.

LOCAL ANÆSTHESIA.

PRELIMINARY OBSERVATIONS.

Whether pain be the result of disease or be caused by surgical interference, the first and most natural impulse is to seek relief in local applications; we find, therefore, that such applications have been in vogue from the earliest times. The use of inhalations of the vapours of ether and chloroform quickly supplanted the less certain and somewhat empirical local methods formerly employed, and it is only during the last ten or fifteen years that the production of local anæsthesia has been systematically studied; and it is even more recently that any attempts have been made to define its advantages and limitations. It is to Continental and American surgeons that we are chiefly indebted for our knowledge of the subject; in this country, the plans advocated have met with but a limited amount of support.

Advantages.—It is claimed for local anæsthetics that no previous preparation of the patient is required; that they are, on the whole, more portable and more available than most general anæsthetics; that they are easy of application; that it is sometimes of advantage that the patient should be able to assist the surgeon in his manipulations, *e.g.* by forcing down a hernia; that they can often be used when a general anæsthetic would be inadvisable, *e.g.* in cases of collapse, and when the patient has an unnatural dread of a general anæsthetic; that, on the whole, some of the methods are safer, and are less likely to be followed by disagreeable after-effects. Against this list of advantages must be balanced the **objections** that they are uncertain in action, and cannot always be relied upon to produce the desired effect, so that it is usually necessary to hold a general anæsthetic in reserve, to be used if required; the tissues are not always completely relaxed; the appearance of the surrounding parts is so altered by the œdema, etc., that dissection becomes almost impossible, and it is open to question whether the healing of the wound be not retarded and the liability to sepsis increased; the fear of the operation, and the very disturbing element of the sight of instruments, blood, etc., has always to be reckoned with, even in the apparently robust and firm-minded.

Kocher [1] is of opinion that the ordinary methods of local anæsthesia are not always so absolutely painless as its advocates maintain, and that it sometimes scares patients from having a subsequent and, perhaps, more necessary operation performed.

Cases suitable.—A careful study of the lists which have been published of operations which can be and have been performed by the aid of local anæsthetics, and having regard to the attendant circumstances of the cases recorded, leads one to the conclusion that, as far as our present knowledge goes, the chief occasions on which local can claim any real advantage over general anæsthesia are as follows, viz. :—

(1) In very brief cases where no dissection is required, *e.g.* simple puncture or incision of small abscesses, and when nitrous oxide is not available or is objected to.
(2) In the aged, whose whole nervous system and tissues generally are often less sensitive than in younger people.
(3) In those who are much collapsed, or feeble and emaciated, and in whom, therefore, there is reason to fear the effect of a general anæsthetic in depressing the already reduced vitality.
(4) In opthalmic surgery, in acute lung troubles, and in some operations involving the superficial mucous membranes, *e.g.* nasal polypi.

Although special preparation of the patient is not so imperatively called for as with general anæsthesia, it is, nevertheless, of advantage that the general condition should be improved by careful regulation of the diet, etc., for a few days beforehand. Purging or starving are not, of course, at all necessary; in fact, it is better that the patient should have a cup of hot broth or beef-tea immediately before the operation; this may counteract any tendency to syncope, and for the same reason a little stimulant is not objectionable. Whenever possible, the patient should be recumbent.

Methods.—The local methods most in use at the present time

[1] Kocher, *Operative Surgery*, 3rd English edition, p. 17.

may be considered under the following heads, viz.: (1) Freezing; (2) Drugs, either applied to the surface or injected into the tissues; (3) Spinal injections.

FREEZING.

The anæsthetic properties of intense cold have long been made use of in practical surgery. In operative work, the cases most suitable for freezing are those which do not involve any large area of surface, but which only require a short, simple incision or puncture, *e.g.* opening a superficial abscess. The method is open to the special objections that the tissues are apt to become so hard, that it is sometimes difficult to cut through them, so no dissecting operation can be carried out; and that the process of thawing is often accompanied by much pain, the healing is retarded, and the tissues are liable to slough.

The late Sir Benjamin Ward Richardson was a great advocate for freezing anæsthesia, and introduced the **ether spray.**

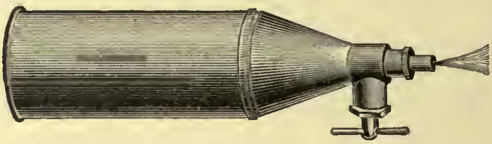


Fig. 218.—Metal Bottle containing Anæstile.

The most convenient adaption of this principle of freezing by evaporation is seen in the use of tubes containing **ethyl chloride, anæstile,** and other fluids of low boiling point (Fig. 218). In these tubes, the heat of the hand suffices to drive a stream of the liquid through a minute hole in the nozzle, and at a distance of a few inches the jet is broken up into a fine spray, and, the part upon which this spray falls, is quickly frozen. These substances appear to be rather more rapid in action than pure ether, to produce a sufficient, but not too great a fall in temperature, and, therefore, the hardness of the skin, and the after-smarting are less obvious objections than when simple freezing, or the ether spray are employed. In using these tubes, care must be taken that the nozzle is held far enough off the part to enable the stream of fluid to fall in a fine shower upon the surface, otherwise, free evaporation does not take place and the freezing is much delayed.

DRUGS APPLIED TO THE SURFACE.

Many drugs, partly by their direct action upon the nerve endings, partly by the pressure of the fluid injected, partly by interfering with the blood supply of the part, have an anæsthetic action upon the tissues in the immediate vicinity of their point of application. For instance, an incision made into a tissue upon which pure carbolic acid, or even a solution of 1 in 20, has been painted, will hardly be felt, but this plan is not to be recommended. The drug generally employed is **cocaine** or one of its derivatives, such as eucaine. Cocaine is the crystalline, active principle of the leaves of the coca plant (*erythroxylon coca*), and its chemical formula is $C_{17}H_{21}NO_4$. The alkaloid itself is nearly insoluble in water, but the hydrochlorate is freely soluble, and is the form in which the substance is generally used. Solutions of this salt are particularly prone to decomposition, and numerous forms of infective bacteria frequently appear. To a considerable extent, this is prevented if 5 per cent. of salicylic acid be added to the solution.

When first introduced into surgical practice, the use of 5 per cent. and 10 per cent. solutions was advised, and these are about the strengths still usually employed in this country. On the Continent and in America, however, where, as already mentioned, the subject of local anæsthesia has received much attention, rather larger quantities of much weaker strength (1 or 2 per cent.) are used, so as to avoid the untoward symptoms which frequently occur when the more potent solutions are employed. In any event, not more than from $\frac{1}{2}$ to $\frac{3}{4}$ grain of the drug itself should be injected hypodermically at a single sitting.

In using cocaine, it is particularly advisable that, whenever possible, the patient should be recumbent, and, as a useful precaution, a cup of broth or beef-tea, or an alcoholic stimulant, may be given beforehand.

The following are the principal plans adopted, viz. :—

(1) **Instillation.**—In ophthalmic surgery a few drops of the solution are placed in the eye, and the instillation is repeated at intervals of three or four minutes, until a sufficient degree of anæsthesia has been obtained; this is usually after the lapse of from five to ten minutes.

(2) **Spray.**—This is useful in operations about the nose and larynx. A convenient form of spray-producer is shown in Fig. 219. A few drops are sprayed at intervals over the surface to be operated upon, as with instillations.

FIG. 219.—COCAINE SPRAY FOR THROAT AND NOSE WORK.

(3) **Painted** on the surface, *e.g.* mucous membranes, etc. Or a pledget of cotton wool soaked in the solution may be allowed to remain for a few minutes in contact with the area of operation. This latter plan is useful in operations about the anterior nares and aural meatus, but mere painting on the unbroken skin is of but little service.

Dangers.—Many people are particularly susceptible to the action of cocaine; even a few minims sprayed upon the throat may give rise to a train of symptoms of a really alarming character, such as vertigo, dryness of the mouth, dilated pupils, cold extremities, palpitation, slow pulse of high tension, restlessness and delirium, and several fatal cases have been recorded. In using cocaine, therefore, it is particularly advisable that, whenever possible, the patient should be recumbent, and, as a precaution, a cup of hot, strong beef-tea, or an alcoholic stimulant may be given beforehand. Should alarming symptoms develop, the patient must immediately be placed recumbent, hot bottles applied to the extremities, stimulants given, and other precautions taken to avoid collapse. Amyl nitrite given in the usual way is said to be a very efficient antidote. It is claimed by some that these poisonous effects may be avoided if antipyrin be added in the proportion of 8 grains to each grain of cocaine contained in the solution. Nowadays it is the custom to add a few drops of the 1 in 1000 solution of adrenalin (an extract of the supra-renal body) to the cocaine solution, and this is said not only to increase the safety of the drug, but also to render the tissues more anæmic.

DRUGS INJECTED INTO THE TISSUES.

Of late years certain allied synthetic compounds or derivatives of cocaine have been introduced, and appear likely to supplant cocaine for many purposes, especially for injections into the tissues. The best known of these are: **Tropocaine,** dose 1 or 2 c.c. of a 5 per cent. solution; derived from Java Coca; **Eucaine,** dose up to 6 grains see below; **Novocaine,** dose from $\frac{1}{5}$ to 1 grain; **Stovaine,** dose from $\frac{1}{3}$ to $\frac{3}{4}$ grain; **Alypin,** dose $\frac{1}{20}$ to $\frac{1}{2}$ grain. While equally efficacious, these bodies appear to be far less likely to give rise to toxic symptoms than cocaine itself. It is customary, however, to add a small amount of **Adrenalin** to the solutions as indicated above.

In any plan that may be employed, it is of the utmost importance that both the solutions and the instruments, used for the purpose, should be absolutely sterile. The solutions should be made with isotonic salt solution, and the sites of the injections, the anæsthetist's hands, etc., as thoroughly washed and purified as for a major operation.

Apart from lumbar injections (which will be dealt with separately), the following are the principal plans adopted.

HYPODERMIC INJECTIONS.

In this process the procedure is sufficiently simple. The solution is injected, a few drops at a time, over the whole area of the operation; when necessary some of the injections are carried beyond the skin into the muscles or other deeper tissues. Care must be taken that the maximum dose of the constituent drug is not exceeded, the solution being diluted to the required strength.

The pain of the punctures may be overcome by freezing the surface with a spray of anæstile, or by making the first prick *endermically* and extending the subsequent punctures deeper and deeper from the margins of the wheal thus raised.

Infiltration.—In this process reliance is placed upon the quantity of fluid injected rather than upon any specific action of the minute quantities of the drugs that it may contain. Schleich, who introduced the plan, adds from 1½ to 30 grains of cocaine to a quart of water, but Kocher considers even this small quantity unnecessary.

The technique is practically the same as in the hypodermic process, except that the injections are carried out much more systematically, and the tissues below and all round the operation area are thoroughly flooded with the solution, from 1 to 15 ounces being used.[1] The great œdema produced by this plan is thought by some, who have tried, it to be very objectionable in itself, and also to retard the healing process (Köcher op. cit.).

CONDUCTION ANÆSTHESIA.

In this process the injections are made either into (endoneural) or round (perineural) the principal nerve trunks supplying the area of operation; these may or may not be at some distance away from the site of the incisions. The anæsthesia is rendered more effective and prolonged if a constricting band is placed round the limb above the point at which the search for the nerve is about to be made. The search for the nerve trunk may be made under the influence of an hypodermic injection, and if, to the latter, an addition of from 1 to 3 drops of the adrenalin solution be made, it will act almost as well as a constricting band. In regions of the body where the sensory nerves have already taken a subcutaneous course, *e.g.* the hand or foot, it may suffice to make a circular or semi-circular band of subcutaneous injections a little way above the part.

[1] Barker, who in this country has employed this method systematically, uses Eucaine 3 grains, Sod. Chlor. 12 grains in 3½ ounces boiled water. Half the quantity may be injected, and by the addition of ♏10 of adrenalin (1 in 1000) the toxic action of the eucaine is restrained and as much as 7 ounces of the solution can be used in major operations. *British Medical Journal*, ii., 1904, p. 1683; and *Practitioner*, September 1907, p. 329.

Kocher thinks very highly of this process, which he believes will come more into vogue when the anatomists have supplied us with more accurate maps of the nerve distributions of the body; as far as the cutaneous nerves are concerned this appears to have been done to his satisfaction by Spalteholtz, whose illustrations Kocher reproduces.[1]

Venous Anæsthesia.—In this process, introduced by Bier in 1908 and applicable only to the extremities, the area of operation is rendered as bloodless as possible by elevation of the limb, the use of elastic bandages, and the firm application of the tourniquet. A superficial vein is then opened and a canula tied in. From 100 to 200 c.c. of a 0·5 per cent. solution of novacaine are forced into the vein and allowed to diffuse over the site of the operation. Complete anæsthesia appears in about fifteen minutes and should last until the tourniquet is removed. The proceeding is a complicated and difficult one, and the results obtained in this country [2] can hardly be considered satisfactory.

SPINAL ANÆSTHESIA.

In 1899 Professor Bier, of Berlin, demonstrated the possibility [3] of producing anæsthesia of the lower extremities by the injection of cocaine into the sheath of the spinal cord in the lower lumbar region. Since that date the method has been employed with increasing frequency, and may now be considered to have obtained a recognised position in anæsthetics. The use of cocaine itself for lumbar puncture has been practically abandoned, its place being taken by one of the allied compounds referred to on p. 484, the technique of the proceeding being the same in any case.

Cases suitable.—Theoretically, this method is applicable in all operations below the level of the umbilicus, and Jonnesco, of Bucharest, maintains that, by the addition of small quantities of strychnine to the solutions, he is able to obtain a perfectly safe and satisfactory anaglesia, even, as high as the vertex,[4] but I hardly think that he has succeeded in convincing English anæsthetists and surgeons on this point.

In the present imperfect state of our knowledge as to the ultimate after-effects of these injections, it is better, perhaps, that they should only be used when it is considered, that they possess distinct advantages over the ordinary methods of general anæsthesia; as, for instance, in such types as the following, viz: (1) Severe injuries to the lower extremities, whether an operation is contemplated or not, the puncture being made as soon after the accident as possible. Much weight is to be attached to the view that 'shock' is thereby greatly diminished. (2) In operations upon

[1] Kocher, *Operative Surgery*, op. cit. p. 18.
[2] Page and MacDonald, *Lancet*, October 16, 1909, p. 1135.
[3] *Deutsche Zeitschrift f. Chirurgie*, Bd. 52, September 1899.
[4] *British Medical Journal*, November 13, 1909.

the lower extremities (especially when the bones are fractured), which are likely to last for upwards of half-an-hour in adult males of the phlegmatic or robust type. The muscular relaxation is superior to that obtained with ether, etc. (3) When the physical condition of the patient contra-indicates the employment of a general anæsthetic, *e.g.* severe pulmonary and cardiac disease, etc. (4) In elderly people with degenerate arteries, *e.g.* diabetic gangrene.

On the other hand, I am doubtful whether one is justified in urging the adoption of this plan upon women (at any rate not in operations above the knee), children, the highly neurotic, or for trivial operations.

It is one of the advantages of this method that but little **preparation** of the patient is called for. In these as in other cases it is, perhaps, better that the patient should have a few days' rest prior to the operation, but there is not the same urgency as regards the limitation of the diet.

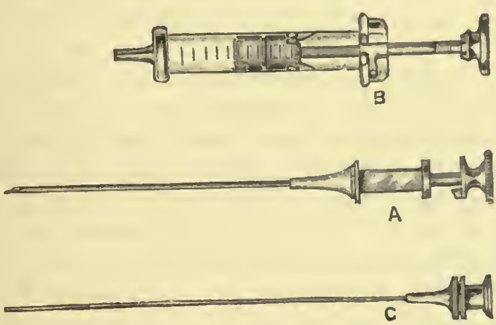


FIG. 220.—SYRINGE AND NEEDLES FOR SPINAL ANÆSTHESIA. A, Hollow needle with solid stillette; B, Syringe; C, Hollow stillette.

Apparatus and Procedure.—My own experience is almost entirely limited to stovaine prepared after Barker's formula (stovaine 0·05 gm., glucose 0·05 gm. to water 1 c.c.), supplied by Billon of Paris in capsules containing 2 c.c. of the sterilised solution. A special syringe is required of at least 2 c.c. capacity, and capable of prolonged boiling. The needle should be fairly stout and about 8½ cm. long, and kept well sharpened; it should be fitted with a solid stillette, and it is, perhaps, of advantage to have in addition a hollow stillette, which can be fitted to the syringe and thrust through and project just beyond the tip of the puncture needle when the latter is *in situ* (Fig. 220). The procedure is as follows: The hands of the anæsthetist are thoroughly disinfected, and the syringe, etc., well boiled. Stovaine is said to be absolutely neutralised by the faintest trace of alkali, so soda must not be used in boiling the instruments, and all soap must be completely rinsed off the hands. The hollow stillette is fitted to the syringe, and the tip of a capsule being broken off the whole of its contents are drawn up into the syringe. The patient is placed upon the operating table, and is either raised to the sitting position, or is turned upon the same side of the body as the site of operation; in either case the head must be thrust well downwards towards the knees, so as to open out the lumbar interspaces as much as possible. The skin over the lower lumbar region and the hands of the anæsthetist are washed and disinfected as for an operation.

The puncture is usually made in the third interspace (*i.e.* between the third and fourth vertebræ), which may be best located by taking an imaginary line between the crests of the ilia; this line will fall across the spine of the fourth lumbar vertebra, and the third space is above. The second or even the first interspace may be chosen, but in the fourth space the theca is apt to evade the needle.

The spot selected may be first frozen with a spray of anæstile. The needle, containing the solid stillette and held strictly horizontally, is passed through the skin in the middle line immediately above the spine of the fourth vertebra. After the first plunge through the skin, the needle is advanced more cautiously, and at a depth of from 2 to 2½ ins. can be felt to enter the spinal canal, when the stillette may be withdrawn. Frequently, however, the needle impinges upon bone, when it must be drawn back about ½ in., its direction altered and the entrance into the canal carefully sought for. A further advance of the needle by from ¼ to ½ in. should result in the perforation of the theca and the escape of the cerebro-spinal fluid. It is important that this fluid should escape freely and the needle should be rotated upon its axis to ensure this; usually from 5 to 10 c.c. are collected in a test tube, but this is not essential. In the passage of the needle a vein is sometimes punctured and free blood comes out, but this usually disappears on pushing the needle forward; or the first few drops of the fluid may be mingled with blood, but this is of little importance.

The fluid having run clear, the hollow stillette to which the syringe containing the solution has been attached, is passed through the puncture needle, and the stovaine slowly injected, care, of course, being taken to avoid the introduction of air bubbles. For adults, I usually inject the whole 2 c.c., corresponding to ⅘ grain of stovaine; but for children, of course, much less is required.

After the injection, both shoulders and legs are slightly raised. Motor paresis is the first to develop, and the anæsthesia should be complete in from three to eight minutes. The anæsthesia has been known to extend as high as the clavicle, but more often it does not reach higher than midway between the umbilicus and the ensiform cartilage. Sensation commences to return after about an hour, but is not completely restored for some hours.

Difficulties and After-effects.—Apart from the intricacies of the passage into the spinal canal, the chief difficulties and dangers connected with this method are:—

(1) Total or partial failure to produce the requisite degree of anæsthesia. These failures are mostly due to imperfect perforation of the theca; this may be owing to the puncture being made too low down, or to the needle being blunt, or held at too great an angle, the theca being then pushed to one side, or only a valvular opening made; in these cases the stovaine solution escapes by the side of the theca itself. Or the solution may have become mixed with an alkali. Although these explanations suffice to explain many failures, there are, in my experience, a few others, which can only be accounted for on the grounds that the patient has some peculiar idiosyncrasy.

It is generally recommended that, in case of failure, a second injection of half a dose should be made, and I have not seen any ill-effects follow this plan. Of course, it causes the patient some additional suffering.

(2) Although syncope and partial collapse are generally due almost entirely fright, the possibility of the occurrence of these symptoms must be borne in mind before deciding upon employing this method in the neurotic.

(3) Of the immediate after-effects the most important are, headache, abdominal pain and retention of urine. The latter may require the catheter; the other symptoms are transient and usually yield readily to full (15-grain) doses of aspirin. More remotely, paralytic affections of the occular nerves, various spinal paralyses, mental disturbances, gangrene of the extremities and not a few fatalities have all been ascribed to the use of this method; but in the present state of our knowledge it would be unwise to attach too great weight to what may, after all, prove to be merely a matter of coincidence; it is perfectly certain, moreover, that many thousand cases have been subjected to this process with the greatest advantage and without the development of any untoward symptoms whatever.

THE EXAMINATION OF THE BLOOD IN SURGICAL CONDITIONS.

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In a comparatively small number of cases an examination of the blood enables a certain diagnosis to be made without further clinical investigation; in the greater number it is only of use as an indication of the more probable of two diseases, and in these the interpretation of the results which are obtained is often a matter of considerable difficulty and uncertainty. In this short outline of the subject reference will be made chiefly to those methods of investigation which are simple to apply, and they will be described in connection with diseases in which these indications are useful and fairly conclusive. For the more difficult methods of blood examination, and for the condition of the blood in diseases other than those dealt with here, one of the larger works on the subject must be consulted.

THE ENUMERATION OF THE LEUCOCYTES.

This is a simple and easy proceeding, and often yields results of considerable value. The requisites are: A Thoma's hæmocytometer, a microscope with a $\frac{1}{6}$th in. lens, and, preferably, a mechanical stage, and a bottle of diluting fluid. Of the latter there are several in use, but Toison's fluid is as good as any. It consists of:

Sodii Sulph.	8 grammes (122 grains).
Sodii Chlor.	1 gramme (15 grains).
Glycerin	30 c.c. (1 oz.).
Aquæ	160 c.c. ($5\frac{1}{2}$ oz.).
Methyl violet	a trace.

(The English equivalents are approximate only.)

It keeps well, but it is advisable to filter it before use. If this fluid is not at hand normal saline solution will answer very well, though it is less easy to distinguish the leucocytes if they are unstained, and it is preferable to use a rather strong saline solution (10 grains to ℥j, or thereabouts) by which means the red corpuscles become crenated and are readily distinguished from the leucocytes. The use of solutions which dissolve the red corpuscles is not so convenient, and will not be described.

Thoma's hæmocytometer consists of a pipette (*S*) and a counting chamber (*a*). The former has a glass capillary tube (with graduations on it) which dilates into a bulb (*E*) containing a glass ball to act as a stirrer.

Above this again there is a short length of capillary tubing with a transverse mark with the figure 101 above it. The longer capillary

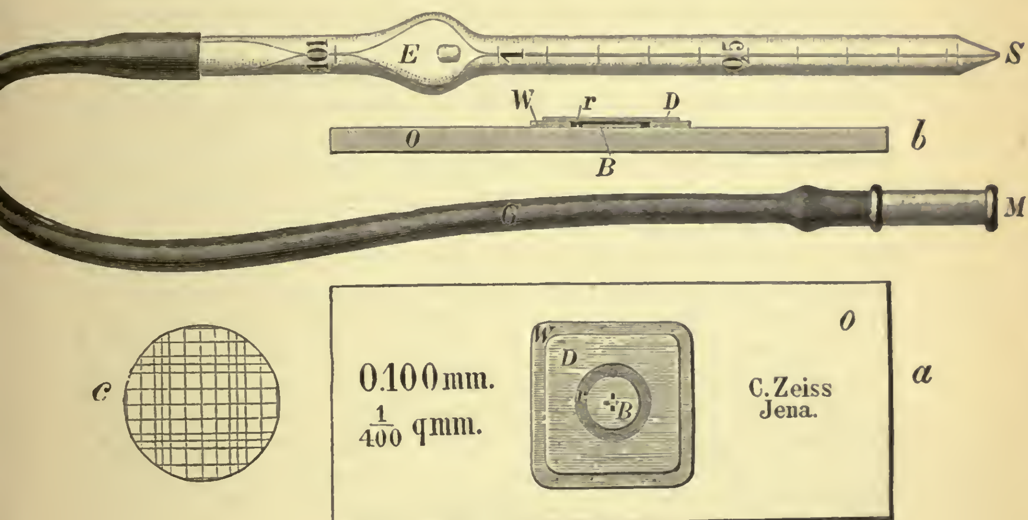

FIG. 221.—THOMA'S HÆMOCYTOMETER.

tube is divided into tenths, and the division nearest the bulb (which is the only one which need be taken into account in the present examination) is marked 1. The volumes of the various parts of the instrument are so proportioned that if blood be sucked up the longer capillary to this mark, and the diluting fluid to the mark 101 above the bulb, the bulb itself will contain blood diluted 100 times.

The counting chamber consists of a plate-glass slide (*O*), to the centre of which a small glass disc (*B*) is cemented. Around this disc, but separated from it by a narrow space or 'moat' (*r*), there is a square plate of glass which is exactly $\frac{1}{10}$th of a millimetre deeper than the central disc (*W*): thus if a drop of fluid be placed on the central disc and a perfectly flat cover-glass (*D*) be placed in absolute contact with the outer square ring it will squeeze the drop of fluid into a perfectly uniform layer $\frac{1}{10}$ mm. in depth. The central disc (a part of which is shown more highly magnified at *c*) is crossed by two series of very fine rulings. These are at right angles, and exactly $\frac{1}{20}$ mm. apart. (Certain of the squares have a double ruling, which need not be considered here.) The area of each square is, therefore, $\frac{1}{20} \times \frac{1}{20} = \frac{1}{400}$ of a square millimetre, and the volume contained between it and the cover-glass is $\frac{1}{20} \times \frac{1}{20} \times \frac{1}{10} = \frac{1}{4000}$ of a cubic millimetre.

The method is as follows. Rub the patient's ear so as to make it hyperæmic, and draw a small drop of blood by making a short sharp prick with a needle: a Hagedorn's needle is by far the best to use for this purpose, as plenty of blood can be obtained from a prick which is entirely painless. Allow a drop of blood to ooze out, and place the tip of the hæmocytometer therein. Apply suction through the india-rubber tube (*M*) provided for the purpose, and draw up a column of fluid exactly up to the mark 1 just below the bulb. Withdraw the pipette, wipe off all blood from the end, insert the tip into the Toison's solution, and suck up the latter (gently revolving the pipette as you do so) until the mark 101 is reached. Remove the tip of the pipette from the Toison's solution, close it by pressing it against the pulp of your forefinger, and shake gently for two or three minutes: the glass ball will act as a plunger, and the blood and fluid will be thoroughly mixed. If you are not making the examination at the patient's bedside a stout india-rubber band may now be stretched over the pipette, so as to close both orifices. It is, however, not advisable to defer the examination more than an hour or so, as very serious errors may creep in, the usual result being that the count is decidedly lowered, probably partly from adhesion of the leucocytes to the glass, and partly from the formation of clumps. If any length of time has elapsed between collecting the blood and making the examination the pipette must be well shaken immediately before the preparation is made.

Now clean the counting chamber thoroughly with water (never use alcohol, xylol, etc., for this purpose) and polish it with a clean, dry handkerchief, and treat the special thick cover-glass provided with the apparatus in the same way. Blow out about half the mixture from the bulb, wipe the end, and then blow out another small drop, which is to be deposited on the central disc; the exact amount can only be learnt by practice. Apply the cover-glass carefully: the central disc should be covered, or almost covered, by the fluid, and there should be no air-bubbles. If this is the case, or if the fluid runs into the moat, it is advisable to clean the slide and cover-glass, and take a fresh drop.

The cover-glass has now to be pressed into absolute contact with the square disc which supports it, so as to spread the fluid out into a layer just $\frac{1}{10}$ mm. deep. If gentle pressure be made, say with a needle, on the cover-glass at any part where it is in contact with the glass below; a series of coloured rings will be seen (Newton's rings), which show that the contact is complete. Pressure should be made in this way at the four corners in turn, and Newton's rings should appear and persist at each. As this is not always easily accomplished I am in the habit of clipping the cover-glass to the slide by means of four pairs of Cornet's forceps. Newton's rings are formed round the tip of each, and persist as long as the pressure is kept up. In a few minutes the corpuscles will all have settled into contact with the disc, and the exact depth of the cell is now immaterial, so that the forceps may be removed.

Proceed to count the leucocytes in the following way. Focus the preparation under the $\frac{1}{6}$th in. lens, using a narrow diaphragm, so as to cut off the excess of light. You will recognise the red corpuscles, which will be unstained and of a very faint yellow colour, and the leucocytes, which are now coloured violet. If you have the centre of the disc in the field, you will see that it is traversed by fine lines crossing each other at right angles, and thus marking off the field into small squares. It is now necessary to arrange the length of the tube of your microscope so that the diameter of the whole field is equal to that of eight of these squares (Fig. 222). To do this it is usually necessary to employ a No. 2 eyepiece, and to draw out the tube of the microscope a little; but the conditions are readily determined by experiment, and, when once found, should be noted for future use. With some lenses it is not possible to get a field of this size. In this case you will probably be able to get one equal to seven squares, and this will serve.

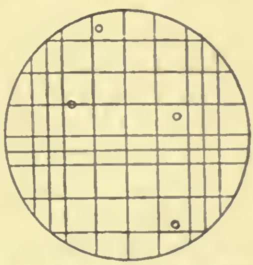

FIG. 222.—THE CENTRAL DISC OF THE COUNTING CHAMBER OF THOMA'S HÆMOCYTOMETER.

Now count the leucocytes which appear on any field of the microscope, and note down their number. Move the slide until you come to a fresh field—and it is here that the mechanical stage is such an advantage—and count these also. Proceed in this way until you have counted forty, or, if greater accuracy be required, eighty fields, and add up the total number of leucocytes seen.

The calculation is now very simple. If you have counted eighty fields it is only necessary to multiply the result by 100, or if forty have been counted, by 200, to obtain the numbers per cubic millimetre. The figures thus obtained are sufficiently accurate for all clinical purposes. In most cases eighty fields should be counted unless the first forty yield figures such that the diagnosis is fairly certain, *i.e.* unless you can say definitely that there is or is not a leucocytosis.

In health a count made with the microscope, arranged in this way, should show an average of about one leucocyte per field (= 80 in 80 fields, or 8000 per cubic millimetre). An average of two per field indicates a moderate leucocytosis, one of three per field a high one.

When it is only possible to obtain seven squares in the diameter of the field it is necessary to count 104 fields and multiply the result by 100, or 52 fields and multiply by 200 to get the number per cubic millimetre.

It is necessary to clean the hæmocytometer pipette *immediately* after use. It is first washed out once or twice with clean water, the fluid being sucked up in the ordinary way, and expelled by being blown out by means of an india-rubber ball, such as is attached to throat sprays. It is then washed out with absolute alcohol or rectified spirit in the same way, and then with ether, and after this has been expelled by the india-rubber puffer a stream of air is pumped through gently until the interior of the whole apparatus is quite dry. This is indicated by the fact that the glass ball in the mixing chamber elicits a clear ringing sound when the pipette is shaken.

In health the leucocytes range between four and ten thousand per cubic millimetre, or may even rise as high as twelve thousand after a meal. The presence of an abnormally high number is termed *leucocytosis*, and this occurs in a large number of conditions. Thus after any severe hæmorrhage, in malignant disease, or in cachexia of any kind, there is usually a moderate leucocytosis, and the numbers may rise to 20,000 or even higher. There is frequently a rise immediately before death (agonal leucocytosis), a fact which has occasionally to be remembered in interpreting the result of a blood-count in a severe illness.

The facts mentioned above are occasionally of value in diagnosis (thus the presence of a marked leucocytosis in a patient suffering from a tumour is some evidence of its malignancy), but the greatest value of the leucocyte count to the surgeon arises from the increased counts present in infective diseases, especially in abscess formation. It is a general rule that there is a leucocytosis in most infective diseases, the most important exceptions being tuberculosis, typhoid fever, measles, and malaria. In most of the others the toxins produced by the infective agent are absorbed into the blood and attract the leucocytes (by positive chemotaxis) from the bone-marrow in increased numbers; the marrow is also stimulated, and the cells are produced in excess. The conditions in which a high leucocytosis occurs are therefore (1) a great production of bacterial toxins, (2) their passage into the blood. To these we must add (3) a certain degree of resistance on the part of the patient: if the intoxication is extremely severe or the patient's resistance low the leucocytes will be decreased instead of being raised in numbers. This phenomenon is rare, and it is usual to find a leucocytosis even in severe infections; its occasional occurrence hardly detracts from the value of the sign, since these cases are commonly diagnosed without difficulty, and yield, moreover, the other blood-signs of an acute infection.

The practical application is best seen in the diagnosis of the presence or absence of pus in acute appendicitis or similar inflammatory conditions. Here there is a decided rise in almost every case, whatever the exact nature of the pathological conditions, but this rise is usually moderate—not exceeding 16,000 per cubic millimetre—if no pus develops. But if the organisms are sufficiently powerful to lead to suppuration the number of leucocytes usually rises to a decidedly higher level, and figures of 20,000 to 30,000 are commonly met with. It must, however, be understood that there is no definite figure which certainly indicates pus, and the true test as to the nature of the processes which are taking place in the affected area is the behaviour of the leucocytes from day to day. With a rising count it is practically certain that the disease is progressing, and when the count begins to fall it may be regarded as a strong indication that it is subsiding. When a diagnosis as to the presence or absence of pus has to be made on a *single* count the most useful rule is to regard any count under 18,000 per cubic millimetre as indicating the absence of suppuration; whilst numbers above this increase the probability of there being pus present in proportion to their height, and when 20,000 is reached the disease will, with very few exceptions, turn out to be suppurative.

The following cautions must be borne in mind: (1) Many other conditions—pneumonia, septicæmia, etc., give a high leucocytosis, and the test loses its value if any of these are present as a complication. (2) The leucocytosis is due to a passage of the toxins into the tissues, and an abscess that is draining freely, *e.g.* into the bowel, will not cause much increase. I have twice seen a fall in the number of leucocytes consecutive to a rupture of an appendicitic abscess into the intestine. On the other hand, in cases in which an abscess has been opened and the fall in the leucocytes which indicates the free escape of the toxic material has occurred, a further rise indicates either the formation of another abscess or the obstruction of a sinus and consequent inefficient drainage. (3) In old thick-walled abscesses in which the causative bacteria are dead, or at least latent, there is no leucocytosis: no toxins are being produced to cause it. It is the process of suppuration and not the presence of pus that is indicated by the test. Hence (as hinted above) a fall in the number of leucocytes does not *necessarily* indicate that the disease is resolving without suppuration, although this is its most usual significance. (4) Tuberculous abscesses do not cause leucocytosis unless a secondary infection with pyogenic bacteria should supervene. (5) Suppurative inflammation of surfaces—such as that of the bronchus, intestine, etc., are equivalent to abscesses which are discharging freely and cause but moderate leucocytosis.

In a few cases of acute suppuration where there is a large surface involved and where the organism is extremely virulent—*e.g.* in a case of general peritonitis occurring in the course of a severe attack of puerperal fever—there may be no leucocytosis, or even a diminution in the number of leucocytes (leucopenia). This is of extremely ill omen, and such patients usually die very quickly: the absence of leucocytosis may be taken to indicate that they are not making any attempt to combat the infection. Such cases are, in my experience, somewhat rare, and, even in very severe cases of peritonitis, leucocytosis is the rule. When they occur the diagnosis (which is usually obvious to the clinician) may be made from the differential count and the presence of a well-marked iodine reaction.

Similarly, a leucopenia may arise in a patient suffering from severe exhaustion and malnutrition even when the infection is not an extremely severe one. Thus when perforation occurs in typhoid fever there is usually a well-marked leucocytosis, which is the more obvious since this disease is normally associated with a normal number of leucocytes, or with a leucopenia: in most cases the count rises to 15,000 within half an hour or so after the perforation occurs, and usually rises still higher. But when perforation takes place in patients who have been greatly reduced in resisting power by a prolonged attack of the disease this rise may not take place. The prognosis is then unusually bad.

There are some other conditions in which a leucocyte count may be of value to the surgeon.

Malignant tumours are usually associated with a moderate leucocytosis —up to 16,000 per cubic millimetre or possibly a little higher, whereas innocent tumours rarely cause any alteration, unless they are inflamed or sloughing. This may be of occasional value in diagnosis, but it is hardly necessary to point out that it affords no means of distinguishing between a malignant tumour and an inflammatory mass. The leucocytosis is, perhaps, specially constant in carcinoma of the stomach, whereas in most of the diseases from which it is often difficult to diagnose it the leucocytes are usually reduced. In this way the test is of some value, but several examinations of the blood should be made.

In glandular enlargement, in which the diagnosis lies between tubercle, Hodgkin's disease, and lymphatic leucocythæmia, a leucocyte count only affords help by affording a means whereby the last-named condition may be diagnosed: it is associated with a large increase in the number of leucocytes, which will be seen to be mainly lymphocytes when stained films are examined. Tubercle and Hodgkin's disease are indistinguishable by ordinary examinations of the blood. A few differences have been described, but they are slight and far from constant, and in either disease the blood may be normal for long periods.

THE DIFFERENTIAL LEUCOCYTE COUNT.

The differential leucocyte count is often necessary to supplement the information obtained by the count obtained in the method described above. The most convenient method is to spread films on cover-glasses and stain them by Jenner's method. Square cover-glasses $\frac{7}{8}$th in. in diameter are best to use, and they must be scrupulously clean. (Clean with nitric acid, wash in water, immerse in alcohol, and polish with a clean handkerchief.) To prepare the films prick the patient as before and, holding a cover-glass with the thumb and forefinger of your right hand, grasping *opposite* corners, take a small drop of blood—about as big as the head of a large pin—on the under surface of the glass. Now take another cover-glass, holding *adjacent* corners between the thumb and forefinger of your left hand, and place this glass under the other, with their centres coinciding, and let the upper cover-glass fall into the lower. The drop of blood will now be flattened out between the two glasses and should just fill up the octagon made by their intersecting edges. Then take hold of the upper cover-glass again and slide the two apart. You should now have two good films. Allow them to dry.

To stain them by Jenner's method take one of the cover-glasses in a pair of Cornet's forceps (film side upward) and pour on a few drops of the stain, which may be bought ready prepared. Allow it to act for three or four minutes, then rinse in distilled or clean rain-water, blot dry between two pieces of blotting paper, dry completely over a flame, and mount in balsam. Examine with a $\frac{1}{8}$th in. or $\frac{1}{12}$th in. lens, and make a count of 400 leucocytes, noting down each sort met with, and reduce the result to a percentage.

The varieties of leucocytes met with in normal blood are:

1. The *lymphocytes*. These have circular nuclei with a variable but usually small amount of protoplasm, which often takes the blue stain (by Jenner's method) more deeply than the nucleus. They vary in size, some being about as large as the red corpuscles, others decidedly larger. They are devoid of granules. In healthy adults they usually form about 25 per cent. of the total leucocytes.

2. *Large hyaline* or *large mononuclear* cells which are similar to the above, but larger, and have indented or twisted nuclei and protoplasm which usually stains faintly. They form about 1–4 per cent. of the total leucocytes, and may be counted in with the lymphocytes, as their variations are of but little diagnostic importance.

3. *Polynuclear leucocytes*, which have twisted (apparently multiple) nuclei and fine pink-staining granules in their protoplasm. The latter may not be seen in badly stained specimens, but the characteristic nuclei are usually sufficient for their recognition. They form about 60 to 75 per cent. of the leucocytes, and are the cells which are especially increased in inflammatory conditions.

4. *Eosinophiles*, which have also twisted (most frequently bilobed) nuclei and large granules which stain a fine pink colour. They form about 1–4 per cent of the total leucocytes, and are usually diminished in severe inflammatory conditions, the diminution being roughly proportional to the severity of the inflammation: their reappearance in the course of an illness of this nature is a good sign.

5. *Mast cells*, which have lobed nuclei and blue-staining granules.

They form about 0·4 per cent. of the leucocytes, and are decidedly increased only in spleno-medullary leucocythæmia.

In disease we may meet with (6) *myelocytes*, which are of variable size, but commonly large, and have single circular or kidney-shaped nuclei which stain faintly, and fine pink-staining granules in their protoplasm Similar cells, but with large granules, are called (7) *Eosinophile myelocytes*, and are only met with in spleno-medullary leucocythæmia.

The *lymphocytes* are greatly increased in lymphatic leucocythæmia, where they may form 99 per cent. of a total count of 60,000–150,000 leucocytes per cubic millimeter or more. They are increased to a less extent, and often only relatively, so that the total count is not raised, in a variety of diseases, the most important of which are pernicious anæmia, tuberculosis (when not complicated by suppurative processes), typhoid fever, etc. A decrease is usually only apparent, and due to an increase of other cells, most commonly the polynuclears.

An increase of the *polynuclears* is the most characteristic mark of acute inflammation, occurring especially in suppuration, where they form 85–95 per cent. of the whole. This is of great importance (1) as confirmatory of the results obtained by the estimation of the number of leucocytes per cubic millimetre, and (2) because it occurs when the leucocytosis is absent from any cause, *e.g.* in very severe septic processes.

They are also increased in other conditions, the most important of which are spleno-medullary leucocythæmia, hæmorrhage, and malignant disease.

An increase of *eosinophiles* occurs in many diseases, the most important of which to the surgeon are those dependent on animal parasites, *e.g.* trichinosis, bilharzia disease, cysticercus and hydatid disease. Thus in cases in which the diagnosis lies between abscess and hydatids of the liver an eosinophilia, even though slight, points to the latter disease. There is also a large increase of these cells in spleno-medullary leucocythæmia.

The following special cases need mention :

In enlargement of the spleen a blood examination may be necessary to exclude spleno-medullary leucocythæmia, which is characterised by an enormously high total count (averaging some 400,000 per cubic millimeter and showing the presence of myelocytes, eosinophile myelocytes, and large mast cells, and an increased number of polynuclears.

In enlargement of lymphatic glands the examination of the blood enables lymphatic leucocythæmia to be diagnosed or excluded. It is characterised by a large increase of the total leucocytes due entirely to an increase in the lymphocytes, which may be mostly of large size. In some cases, which are apparently of this nature, this lymphocytosis may occur without an increase in the total number. In Hodgkin's disease there is no characteristic change, and the blood may be normal until a cachectic anæmia supervenes. In tuberculosis there may be a slight leucopenia with a relative lymphocytosis, but this is rarely sufficient for a diagnosis: in a small proportion of cases a diagnosis may be made from the opsonic index.

THE IODINE REACTION.

The study of the *iodine reaction* or *glycogenic degeneration of the leucocytes* is simple, and often leads to valuable results. Films are prepared as before and mounted (without previous fixation) in

Iodine	1 part.
Iodide of potassium	3 parts.
Mucilage of gum acacia	100 parts.

(This solution must be freshly prepared.)

They are allowed to stain for ten minutes, the excess of the fluid blotted off, and they are examined under a $\frac{1}{12}$th. in. lens, using white light. Normally the protoplasm of the polynuclears should be a pale yellow, but in acute inflammatory conditions, more especially if severe enough to lead to suppuration, they show deep mahogany brown granules or masses, or may stain a diffuse brown colour. This reaction occurs when the total count is not raised. It may be present in other conditions, but its absence in appendicitis and similar diseases is strong evidence of the absence of a suppurative lesion.

THE EXAMINATION OF THE RED CORPUSCLES AND HÆMOGLOBIN.

The enumeration of the red corpuscles is a simple but somewhat tedious proceeding, and is rarely of much value to the surgeon. The process is exactly the same as that used in the enumeration of the leucocytes—in fact, it is now customary to count both the red and the white corpuscles in the same specimen. It is necessary to count the number of red corpuscles which lie on 100 of the small squares into which the Thoma counting-chamber is ruled. This may be done by counting the squares singly and noting down each result, or by counting the corpuscles which lie in each horizontal 'bar' of twenty squares. It will then be necessary to count the corpuscles lying on five such bars. The calculation —presuming that the blood has been diluted 100 times—is then very simple: the total number in 100 squares, multiplied by 4000, gives the number per cubic millimetre. Thus, if 650 corpuscles were found in the hundred squares, the number per cubic millimetre would be 650 × 4000 = 2,600,000. Greater accuracy will be obtained by preparing a second specimen and counting another 100 squares therein: the two results are to be added together and multiplied by 2000.

In health the accepted average numbers of red corpuscles are, for the male, 5,000,000 per cubic millimetre, and for the female 4,500,000, but these numbers are not infrequently exceeded, especially in dwellers in the country.

The chief use of this investigation for the surgeon is that it provides some measure of the amount of blood lost in a hæmorrhage, and enables its regeneration to be watched. When blood is lost the loss involves corpuscles and plasma in equal proportions, and an examination immediately afterwards will show no deviation from the normal. In a short time, however, fluid will be absorbed from the tissues, so that the volume of the blood is restored to its former amount, and, when this has occurred, the ratio of the number of red corpuscles present to 5,000,000 may be taken as a rough guide to the amount of blood lost; thus, in the example quoted, where the number per cubic millimetre was 2,600,000, very nearly half the total amount must have escaped. The process of blood regeneration almost invariably begins by a rise in the number of red corpuscles, which occurs earlier and proceeds more quickly than the increase in the amount of hæmoglobin; the first corpuscles, which are manufactured by the bone-marrow in response to the unusual demand, being less rich in pigment than they should be. The hæmoglobin is, however, the important substance, and more information as to the way in which the regeneration of the blood is proceeding can be obtained by estimating the amount of this substance than by counting the corpuscles.[1]

The most useful apparatus for measuring the amount of hæmoglobin is Haldane's hæmoglobinometer, which is a modification of that of Gowers. Its use involves access to coal-gas; and as this is not always procurable in the country, it is advisable to procure a combination instrument in which both forms are available. They differ only in the standard which is employed for comparison. In Gowers's instruments this consists of a tube containing a jelly tinged with carmine to a tint representing normal healthy blood diluted 100 times. In Haldane's the standard (A) is a solution of CO hæmoglobin of definite strength and representing normal blood diluted 100 times, and saturated with CO or coal-gas. To use either form, place a little water in the diluting tube (B); prick the patient as before; suck blood up to the transverse mark on the special pipette (D); place the tip of this pipette in the water in the diluting tube and blow out the blood, washing out the last traces by sucking up the water once or twice and expelling it. Shake gently so as to mix the blood and water together.

In using Gowers's hæmoglobinometer, place the standard in a good light alongside of the diluting tube: the solution of blood in this should be decidedly darker than the standard, and, if this is not the case, too

[1] Some observers estimate the specific gravity of the blood instead of the amount of hæmoglobin, the two being in general closely related. The estimation of the specific gravity is, however, more difficult, and is rarely required.

much water has been taken, and it will be necessary to shake it all out and begin again. If it is darker than the standard add water drop by drop, shaking after each addition until the two just match. Now read off the height of the column of fluid by means of the graduations at the side of the tube; these indicate the amount of hæmoglobin expressed as a percentage of the normal.

In Haldane's form the blood solution has to be saturated with coal-gas, which is led into the diluting tube by means of the apparatus which is sold with the hæmoglobinometer, and which fits over an ordinary gas-jet (G). It is best to fill the tube with gas, and quickly cover it with the finger and shake for a few seconds. Repeat this several times, and you will find the colour of the solution changes from crimson to pink, the tint being exactly like that in the comparison tube. Now dilute as before until the two are an exact match. It is much more easy to determine this point with this apparatus than with that of Gowers, and the results are more accurate.

FIG. 223.—HALDANE'S HÆMOGLOBINOMETER.

A, Glass tube containing blood solution of standard tint.
B, Graduated tube.
C, Rubber stand for tubes A and B.
D, Capillary pipette and suction tube; wires for cleaning the pipette are supplied.
E, Bottle with pipette stopper.
F, Glass tube holding six lancets.
G, Tube and cap for fixing over ordinary gas burner.

The amount of hæmoglobin is to be regarded as the most accurate criterion of the degree of anæmia present. Thus it occasionally happens that the red corpuscles are present in normal numbers, but that the hæmoglobin is greatly reduced, and in such cases the patient must be regarded as being anæmic in proportion to the deficiency in hæmoglobin, in spite of the normal number of corpuscles.

An estimation of the amount of hæmoglobin enables the surgeon to measure roughly the amount of blood lost, and where the hæmoglobin falls from day to day—in the absence of other causes for such a fall—a diagnosis of internal hæmorrhage may be made in some cases. Rules have been laid down with regard to the suitability of patients for operation in presence of a severe anæmia, but these can be of little practical value. If a patient is decidedly anæmic, no surgeon would choose to operate except in cases of necessity; and in such cases he would not stay his hand because of the anæmia. Still, Mikulicz's rule may be quoted. It is that no operation should be done on patients with less than 30 per cent. of hæmoglobin.

The examination is of some value in the diagnosis and prognosis of sepsis. Localised inflammatory disorders are usually accompanied by a moderate degree of anæmia, which is roughly proportionate to the extent and severity of the disease, and its duration. In general sepsis this is usually much more marked, and the hæmoglobin may fall to a very low figure in a few days. This is a sign of very bad omen, and a progressive fall in the hæmoglobin is one of the surest indications of the progress of the disease. On the other hand, a cessation of the fall, or a rise, are extremely favourable signs, and will frequently form the first indication of a turn for the better. This is especially useful in puerperal cases.

Next to sepsis, the disease in which anæmia develops most rapidly is malaria, and a rapid fall of the hæmoglobin may sometimes permit of a diagnosis between this disease and others (such as pneumonia or typhoid fever) in which the anæmia does not develop so quickly.

The term '*colour index*' is used to denote the average amount of hæmoglobin contained in each corpuscle, the normal amount being regarded as 1. To obtain it, it is necessary to find the percentage amount of red corpuscles present, 5,000,000 being regarded as normal; thus, 2,000,000 red corpuscles per cubic millimetre constitutes 40 per cent. of normal. The percentage of hæmoglobin present is then divided by the figure thus obtained. Thus, if in the example just quoted there was 24 per cent. of hæmoglobin in the blood the colour index would be $\frac{24}{40} = 0{\cdot}6$, *i.e.* each corpuscle would contain only six-tenths of its normal amount of hæmoglobin.

In most forms of anæmia the colour index is slightly below unity: in chlorosis it is usually very low, 0·5 or less; and in pernicious anæmia it is above the normal.

THE BACTERIOLOGICAL EXAMINATION OF THE BLOOD.

This is a matter of some difficulty, and expert help should be called in where possible. Cultures are necessary in almost all cases, and the blood must be taken direct from a vein, for contaminations are almost certain if the culture-material is taken from a puncture in the skin, no matter how carefully this may have been sterilised. I prefer a special pipette made like a hypodermic syringe, but longer, and devoid of a piston; but in the absence of this, an all-glass 5 c.c. or 10 c.c. exploring syringe will answer very well. Cultures should be made in broth and on the surface of a solid medium, such as agar or blood serum, and these materials must be at hand at the time of the operation.

Proceed as follows: Put the syringe in a steriliser to boil; it should be kept at the boiling point for at least ten minutes, and should be allowed to cool spontaneously before being removed from the water. Prepare the skin over the antecubital fossa as though for an operation, washing off the antiseptic used by means of a stream of methylated spirit immediately before the puncture is made. Place a narrow ligature round the upper arm and tie it fairly tightly, so as to obstruct the veins. Select a large and prominent vein, and (having fitted the syringe together) puncture it by passing the hypodermic needle obliquely through a fair thickness of skin; by doing so you will lessen the chance of skin contamination and of leakage of blood after the operation. Direct the point of the needle *away* from the body, so as to face the current of blood, and as soon as the vein is entered the blood will commence to rise in the syringe, pushing the piston before it; it is unnecessary, and indeed useless, to apply suction. When the requisite amount has been taken, withdraw the needle and get an assistant to remove the ligature; if this is not done there may be leakage into the tissues. A pad of cotton-wool applied with collodion will usually be sufficient dressing for the puncture.

The cultures must be made at once, or the blood will coagulate. In most cases the best way to proceed is to squirt a few drops on to the surface of an agar tube, to put about 1 c.c. into an ordinary broth tube, and the rest into a small flask holding some 100 c.c. of broth. These are to be incubated at the body temperature, and will (in positive cases) usually show signs of growth in 24–36 hours, though sometimes there may be no appearance of bacteria before the end of the third day. For the methods of examining these cultures and the identification of the various organisms which may be present a work on bacteriology must be consulted.

THE OPSONIC INDEX.

The method by which the opsonic index is estimated is fully described by Dr. Whitfield (see Vol. II.), and its application to diagnosis is all that need be discussed here. It is rarely required except in the diagnosis of tuberculous infections, and it is in these that it has been most carefully studied. Unfortunately it is only in a comparatively small minority of cases that it is of value, since it is found that a patient suffering from tuberculosis may have a perfectly normal index as compared with a healthy person. This, however, is not always the case, and it is common to find tuberculous patients having indices decidedly higher or lower than any met with in healthy persons; thus it may fall to 0·3 or rise as high as 2. In health the extreme limits may be regarded as 0·8 and 1·2, and the figures below or above these may be looked upon with suspicion proportional to their remoteness from these limits; thus, 0·5 or 1·5 almost certainly indicate tuberculosis.

Another method which may be of value, where the simple determination of the opsonic index yields inconclusive results, is to follow it by an injection of tuberculin such as is now used therapeutically—say $\frac{1}{800}$ of a milligram of new tuberculin. This is apparently quite harmless in all cases, and is usually not followed by any febrile reaction. In health it does not usually cause any fall of the opsonic index, whereas when there is a tuberculous lesion present there is a marked fall of the index (negative phase) followed by a rise, in most cases to a higher level than the original one. When this examination is made the determination must be performed with great accuracy and repeated in twenty-four hours, and again in a day or two, since the negative phase may be very short or may be delayed. The results are more certain if a larger dose of tuberculin is given, but this is not always desirable.

The following cautions should be noted. The determination of the opsonic index is by no means an easy process, and even in skilled hands there is necessarily a certain amount of error. As ordinarily performed this may amount to 10 per cent. or so, though with great pains it may be reduced somewhat: hence no importance should be attached to small differences. Secondly, the opsonic index affords no clue to the locality or the size of a tuberculous lesion. In the third place, the opsonic index does not, at present, afford any indication as to prognosis.

THE FREEZING POINT OF THE BLOOD OR SERUM.

The freezing point of the blood or serum is sometimes estimated, the results obtained being thought to indicate the functional activity or the reverse of the kidneys, and to allow an estimate of the danger of an operation to be formed when these organs are affected. The freezing point of any watery solution is an index of its molecular concentration: the greater the number of molecules it contains the lower the freezing point. In health the kidneys excrete the salts which occur in the blood, passing them into the urine, so that the freezing point of the blood should remain constant and at a higher level than that of the urine. In disease this may not occur, and one of the most constant signs of functional imperfection of the kidney is a lowering of the freezing point of the blood due to a retention of salts, etc., which should be eliminated by the kidneys. In health the blood usually freezes at $-0{\cdot}56°$ C., and when this is the case we may, as a general rule, deduce that the function of elimination is being performed efficiently. Thus, when one kidney is known to be diseased, and the blood freezes at this point, it is highly probable that the remaining kidney is sound, and capable of acting as an eliminator for the whole of the body. On the other hand, a decided fall in the freezing point (to $-0{\cdot}6°$ or lower) is more likely to indicate a lesion of both kidneys, and a danger of uremia after nephrectomy, or the performance of any severe surgical operation. Unfortunately, however, these results, though generally true, are subject to numerous exceptions; thus the freezing point of the blood may be lowered in any condition leading to cyanosis, in severe anæmia, diabetes, etc. Further, if the blood is hydræmic to begin with, renal disease may lower the freezing point until it reaches the normal, and the examination of the blood will show no deviation from the healthy condition.

A great objection to the use of this method is that large amounts of blood—10 c.c. or more—are necessary. This, together with the uncertain interpretation to be placed upon the results which it yields, prevents it from being used much, in this country at least. The process for the determination of the freezing point is not difficult, and the results obtained are very accurate. It is fully described in Ewing's 'Clinical Pathology of the Blood.'

The examination of the molecular concentration of the blood (or serum) and of the urine which is being secreted at the time the blood is taken is of greater promise. It may be carried out by the determination of the freezing points of the two substances, or by a method due to Wright (*Lancet*, April 2, 1904, and October 21, 1905) which has the great advantage that only a very small amount of serum is necessary. It depends upon the fact that red blood corpuscles are hæmolysed in distilled water or in solutions of salts below a certain molecular concentration about equal to that of 0·42 per cent. NaCl. The patient is made to empty his bladder and a sample of blood is collected. As soon as possible after this he is again made to empty his bladder, and a sample of urine thus obtained. Various dilutions of the serum and of the urine are now made with distilled water, and to each a definite volume of blood (or an emulsion of blood corpuscles) is added. This is done by means of a capillary pipette, with a very fine point at one end and an india-rubber nipple at the other, and similar to those used for the determination of the opsonic index. A unit mark is made at about one inch from the tip, and two volumes of the dilution of the serum or urine are taken and one of the blood or emulsion or red corpuscles. These are mixed together and sucked up into the pipette. This is examined by reflected light to determine whether the corpuscles are completely hæmolysed: if this is the case the fluid will be translucent and appear dark by reflected light, whereas if the corpuscles are intact it will be opaque and appear much lighter by reflected light. When a series of these dilutions is made and sucked into one pipette (each separated by a small column of air), the point at which complete hæmolysis occurs is readily seen.

In health, or in the absence of renal disease, the urine should contain a greater amount of salts, etc., than the serum, and thus should require greater dilution in order to bring about complete hæmolysis. Thus if the urine just hæmolyses when diluted 16 times with distilled water, the serum ought to do so when diluted about 8 times: the excretory coefficient is then $\frac{16}{8} = 2$. This coefficient is usually about 2·2 when the kidneys are healthy: when they are diseased it may fall to 1 or lower. In order to get reliable information the patient should not have drunk copiously immediately before the samples are taken, and his food for some time previously should contain a fair amount of salts, otherwise the kidneys may not be called upon to perform as much work as they are capable of doing. When performed in this way the test appears, as far as our experience has gone at present, to be a reliable one, although a large amount of information is still necessary before the information which it yields can be regarded as conclusive.

SUMMARY.

The following is a brief *résumé* of the condition of the blood in some of the diseases, in which it may afford some assistance in diagnosis.

Suppuration.—There is a marked leucocytosis, the numbers rising to about 18,000, or usually higher. The increase is due mainly to an increased influx of polynuclear cells, which may form 95 per cent. of the total leucocytes: the lymphocytes and eosinophile cells are reduced, especially the latter. The glycogenic degeneration of the leucocytes is well marked.

The red corpuscles show no change, or, in severe cases, there may be a slight anæmia.

Septicæmia.—The changes in the leucocytes are, in general, similar to those of the localised suppuration, but in very severe cases there may be leucopenia instead of leucocytosis: the relative increase of the polynuclears and diminution of the lymphocytes and eosinophiles will occur, and the glycogenic degeneration is usually very obvious.

A progressive anæmia is the rule, and the amount of hæmoglobin lost from day to day may be taken as a rough guide as to the severity of the infection.

A bacteriological examination of the blood will probably show the presence of pathogenic bacteria, but this is not always the case unless repeated examinations are made.

Tuberculosis.—In uncomplicated tubercle there is usually no change other than a slight leucopenia with a relative increase of the lymphocytes. These alterations are, as a rule, insufficient to justify a diagnosis. The red corpuscles are unchanged, except in the later stages, in which the patient becomes cachectic.

A diagnosis may be made in a certain proportion of cases by means of the opsonic index.

In tuberculous meningitis there is a decided leucocytosis, which may reach 25,000. Tuberculous pleurisy is, as a rule, unaccompanied by leucocytosis, but there may be a slight rise.

The occurrence of a secondary infection, *e.g.* in a tuberculous abscess or sinus, causes the appearance of the blood changes described under the heading of suppuration.

Syphilis.—In the earlier stages the blood is usually normal; if the cases is severe, there may be slight anæmia.

In the secondary stage there is marked anæmia, in which the hæmoglobin may fall to 40 per cent. or lower, and a moderate leucocytosis (not often exceeding 15,000) due mainly to an increase of lymphocytes.

In the tertiary stage there is nothing characteristic, though in cachectic cases there may, of course, be a slight anæmia with or without moderate leucocytosis.

Malignant Disease.—In the early stages there may be nothing abnormal, or there may be a slight polynuclear leucocytosis ; it is rarely sufficient to help much in the diagnosis. In later stages there is usually a marked polynuclear leucocytosis, more marked in the sarcomata than in the carcinomata, and in ulcerated than in non-ulcerated tumours. Anæmia frequently occurs (but not always, the blood sometimes appearing to diminish in total volume rather than to become impoverished), and nucleated red corpuscles (normoblasts) may be present in considerable numbers.

In carcinoma of the œsophagus there may be a leucopenia.

In cancer of the stomach the leucocytosis, anæmia, and presence of nucleated red corpuscles is usually well marked. In most cases the anæmia is of the ordinary secondary variety, with a low colour-index ; whilst in others the colour-index is high, and the blood-count closely resembles that of pernicious anæmia, from which it may be distinguished by the presence of polynuclear leucocytosis in place of the leucopenia and lymphocytosis met with in the other condition.

Lymphadenoma.—In the early stages the blood is unaltered in any way. In the later there is the ordinary secondary anæmia, and frequently moderate leucocytosis. It is worth while to emphasise the fact that the disease cannot be diagnosed by a blood examination.

Leucocythæmia.—In the spleno-medullary form there is a vast excess of leucocytes (250,000 or more), which are seen to consist in large measure of myelocytes. There is an excess of mast cells, often of large size, of eosinophile cells, and of polynuclear cells, and eosinophile myelocytes are present. There is anæmia, of the secondary type, and nucleated red corpuscles are usually present. The disease may be diagnosed in most cases by a single glance at a stained film.

Lymphatic Leucocythæmia.—This is associated with a great increase of the leucocytes, usually to 100,000 or more, but sometimes to a much lower figure ; and occasionally in diseases apparently of this type the total numbers are normal. In all cases, however, the relative number of the lymphocytes is greatly raised, sometimes to 99 per cent. There is also secondary anæmia.

Pernicious Anæmia.—This is associated by a raised colour index, which may be as high as 1·8, or even more ; the red corpuscles are reduced out of proportion to the hæmoglobin. Thus it is common to find about 1,000,000 red corpuscles, and when this is the case the hæmoglobin may be 25–30 per cent., instead of the normal 20 per cent. The red corpuscles are abnormal, being larger than normal (macrocytes), small (microcytes), or distorted (poikilocytes). Nucleated corpuscles occur, especially the large forms (megaloblasts), which are almost characteristic of this disease.

The leucocytes are diminished in numbers, and there is a relative excess of lymphocytes (40 per cent. or more).

Chlorosis is indicated by a low colour index (0·5 or often less), the leucocytes remaining normal.

Secondary anæmia (*i.e.* that due to a definite recognisable cause) is indicated by a moderately reduced colour index (0·8 or 0·9, sometimes lower), with a leucocytosis, slight or marked, according to the disease producing it, and caused mainly by an increase of the polynuclears.

Typhoid Fever.—In the earlier stages there is usually no anæmia, and there may even be an increase, due to a concentration of the blood. There is no leucocytosis, the numbers being often below normal, and there is a relative excess of lymphocytes. In the later stages there may be a moderate amount of anæmia.

Perforation of a Viscus.—Here there is a sudden and rapid increase in the number of leucocytes, the figures reached being dependent on the amount of fluid which escapes, its nature, and the resisting powers of the patient. The increase is mainly due to the polynuclear cells.

In the case of a perforated typhoid ulcer the rise is usually well marked, since it contrasts with the low counts previously met with. A severe hæmorrhage may give a similar rise, and must be excluded.

Trichinosis, Bilharzia Disease, Hydatids, etc.—The characteristic feature of these diseases is an increase in the eosinophiles. This is most marked in trichinosis, where it may reach 80 per cent.. It is least marked in hydatid disease, and may, indeed, be absent. In swellings of the liver in which hydatid is suspected a considerable amount of weight attaches to even a slight increase, since the most important diseases with which it may be confounded are usually associated with diminished eosinophiles. In this connection anything over 4 per cent. may be looked upon with suspicion.

Malaria.—The diagnostic feature is, of course, the discovery of the specific parasite. This is not always possible, and, when it cannot be done, some help may be obtained from the fact that there is no leucocytosis, but a relative lymphocytosis, large lymphocytes being specially numerous. The anæmia is usually of very rapid onset, a marked reduction occurring in a few days.

THE WASSERMANN REACTION.

One of the most important services that pathology has been able to render to clinical surgery for some years is the elaboration of a method for the diagnosis of syphilis by means of a blood-test, the great advantage of which is that it can always be carried out in cases in which there is no available material in which the specific spirochæte can be sought. It is somewhat difficult to perform, and hence is not available as a consulting-room test, but the collection of the necessary sample of blood is easy (sufficient being obtained from an ordinary puncture of the finger or ear-lobe) and in skilled hands it yields trustworthy results.

It is based on the phenomenon known as the 'absorption of complement' and discovered by Bordet and Gengou. To understand this it is necessary to be familiar with the terms 'antigen' and antibody.' An **antigen** is a substance (apparently invariably of proteid nature) which, when injected into an animal in which it does not occur naturally, gives rise to the production of a second substance, its **antibody**. Thus diphtheria toxin is an antigen, its antibody being diphtheria antitoxin. Solutions of coagulable proteids (blood-serum, etc.) act as antigens, giving rise to precipitins: bacteria, red-blood corpuscles and other cells are antigens which give rise to a series of antibodies, amongst which are agglutinins and cytolysins. These latter are substances of much importance in regard to the Wassermann reaction. They are antibodies which have the power of dissolving their antigens (or rather the cells containing them) on condition that a third substance is present and that the three bodies are kept at, or near, the temperature of the body. This third substance is called **complement** or **alexin**, and it is not an antibody; it occurs in normal blood-serum and is supposed to play a part of great importance in preserving the body against infections. It differs from the antibodies in being thermolabile, *i.e.* it is destroyed at a temperature of 55° C. in half an hour or at 60° C. in ten minutes.

Let us take an example of the action of these substances. If normal rabbit's serum be mixed with sheep's corpuscles (thoroughly washed in normal saline solution by repeated centrifugalisations) and incubated, no action takes place. If, however, the rabbit be injected once or twice at intervals of a few days with these washed corpuscles, it acquires fresh properties; and if the experiment be repeated, using the serum of this 'immunised' rabbit, it will be seen that this has a solvent action on the sheep's corpuscles; in the former case the latter will settle to the bottom of the tube, leaving a colourless supernatant layer of normal saline solution, whilst in the latter they will be dissolved and yield a crimson solution, in which practically no deposition of undissolved material takes place.

That this new solvent property depends upon the action of two substances, an antibody formed as the result of the injection, and complement, occurring in normal serum, is provable thus: the serum from the immunised animal is heated to 55° C. for half an hour, so as to destroy the complement, and then incubated with the washed corpuscles; no solution takes place. A little fresh serum from a normal (unimmunised) rabbit is then added, and the mixture re-incubated, when solution occurs. This shows that the heated serum of an immunised animal is in itself powerless to effect solution; we have seen previously that fresh normal serum is equally unable, but the two together can do so. Further experiments show that the antibody (which is also known as amboceptor, immune body, etc.) can enter into combination with the corpuscles at a low temperature, and corpuscles thus treated are spoken of as 'sensitised.' In appearance they are unaltered, and when fresh normal serum is added nothing happens until the mixture is raised to a point near the temperature of the body, when solution occurs. Thus we picture the process of hæmolysis thus: the antibody unites to the corpuscles, but without injuring them. If now complement be added it can unite either with the antibody or with the sensitised corpuscle (for this point is not yet settled), yet still without the occurrence of solution unless the mixture be near the body-temperature, when the complement exerts its enzyme-like action and solution occurs.

All cells (with perhaps a few exceptions) appear able to give rise to similar antibodies, amongst others, the bacteria. Thus, the experiments described above could be carried out equally well, using cholera vibrios instead of sheep's corpuscles. The serum of an animal which has been immunised to this organism, contains an antibody which will sensitise it to the action of the complement contained in the normal serum. These antibodies are more or less specific, *i.e.* that for sheep's corpuscles will have no action on cholera vibrios and *vice versa.*

The discovery made by Bordet and Gengou, and since shown to be of universal validity, was that when an antibody and its antigen unite *all* the complement is removed from the serum. For example, if we mix together cholera vibrios (antigen), heated serum from a rabbit which has been immunised to cholera (antibody), and fresh rabbit or guinea-pig serum (complement) and incubate them, all the complement will be removed, and this is proved by adding sheep's corpuscles sensitised by heated serum from an immunised rabbit. No solution occurs, showing that the fluid contains no complement. This gives us a most delicate and sensitive test for the presence of an antigen or of an antibody.

It was applied by Wassermann to the diagnosis of syphilis. The first difficulty was to obtain the antigen, pure cultures of the spirochæte, being, of course, unobtainable. To overcome this, he made use of an extract (in normal saline solution) of the liver of a still-born syphilitic fœtus found to be rich in spirochætes. This we shall call the 'extract' or 'antigen.' The patient's blood is now to be tested for an antibody to the spirochæte, and as a preliminary, it is heated to 55° C. to destroy its complement (this step is not absolutely necessary). A mixture is now prepared of (1) extract or antigen, (2) the heated serum to be tested, and (3) guinea-pig's serum, quite fresh and rich in complement. The three are heated together for an hour in the incubator, so as to allow the union of the three substances to take place, supposing, of course, that the syphilitic antibody is present. Then a mixture of (4) sheep's corpuscles and (5) heated serum from a rabbit immunised to sheep's corpuscles is added, and the mixture again incubated for two hours and allowed to stand in the cold for twelve hours. A positive reaction is indicated by the fact that the corpuscles remain undissolved and form a compact layer at the bottom of colourless fluid, whereas when the reaction is negative they are dissolved, forming a clear crimson solution. Numerous controls are necessary, but exact details of this (the original) process will not be given, since it can only be carried out by an experimenter having facilities for the use of animals. Some simpler methods, which are not beyond the reach of independent workers, will be given.

The most important modification consists in the replacement of the extract described above by an alcoholic extract of a syphilitic liver or of a normal heart—either human, or from a guinea-pig or ox. A convenient method is to take a few grammes of normal heart-muscle, add five times its weight of absolute alcohol, grind the two together and allow it to macerate for twenty-four hours. Then heat the mixture to 60° C. for one hour and filter, and the extract is ready. For use dilute one part of the *clear* solution with nine parts or more of normal saline solution, the exact degree of dilution necessary for any given sample being determined by experiments with normal and syphilitic sera. The alcoholic solution keeps indefinitely, but usually undergoes alterations in strength. Not all extracts act equally well, and none should be admitted for clinical use until it has been used for numerous tests on known bloods, syphilitic and non-syphilitic.

It may be pointed out that the fact that an alcoholic solution of a normal organ acts as an antigen in the test proves that the reaction is not in reality on a par with the Bordet-Gengou reaction, as described above. It was necessary to describe that reaction in order to explain what happens in the Wassermann test, but, as a matter of fact, the latter is at present purely empirical. Its practical value is proved by clinical experience, but the theoretical considerations which led to its introduction are unsound, and at the time of writing we do not know in the least how the complement is absorbed in a positive reaction.

The simplest modification is that introduced by Hecht and advocated by Fleming. It depends on the fact that normal human serum usually contains amboceptor and complement for sheep's corpuscles. It is carried out as follows: The blood to be tested is collected in the ordinary way in Wright's pipettes, allowed to clot and centrifugalised, so that clear serum is obtained. With a fine pipette 1 unit (of about ten cubic millimetres) of this fresh serum is placed in a narrow tube (about $\frac{1}{8}$th in. wide) and mixed with 4 units of diluted alcoholic extract, prepared as above. A second tube is prepared, in which the extract is replaced by normal saline solution: this is an absolutely necessary control. No complement is added, that present in the serum itself being sufficient. The two tubes are incubated for an hour, and then 1 unit of a 10 per cent. emulsion of sheep's corpuscles, which have been washed by at least three centrifugalisations from normal saline solution, is added and well mixed in. The mixtures are returned to the incubator for two hours ; it is an advantage to stir or shake them from time to time. They are then allowed to settle. In a positive reaction the first tube will show no hæmolysis, whereas in the second the hæmolysis will be complete ; in a negative one each tube will show complete hæmolysis, and not infrequently it happens that there is no hæmolysis in either tube. This shows that this method is unavailing and another process must be used. The results may be given in tabular form thus :—

		Positive reaction	Negative reaction	Indeterminate
1. Serum 1 part, Extract 4 parts	Incubated 1 hour and 1 unit emulsion sheep's corpuscles added	No hæmolysis	Hæmolysis	No hæmolysis
2. Serum 1 part, Normal saline 4 parts		Hæmolysis	Hæmolysis	No hæmolysis

Numerous controls ought to be added, *e.g.* tubes containing 4 units of extract and of normal saline, but no serum ; the serum from a known syphilitic and a known non-syphilitic person, which ought to react as theory demands.

Sheep's corpuscles are not always easy to obtain, and to avoid this difficulty the author of this article uses the following method, based on a process introduced by Tschernagubow, but rather more convenient in detail. The corpuscles used are human ones, well washed by repeated centrifugalisations (at least three) from normal saline solution. Apart from these and the extract, the only requisite is heated serum from a rabbit which has been injected with human corpuscles and thus contains an antibody to these structures. This serum keeps well, and can be put up in ampoules in quantities sufficient for a number of tests, so as to be always at hand. The earlier part of the process is exactly the same as in Fleming's method. After the first incubation 1 unit of a mixture of 1 volume of washed human corpuscles and 4 parts of immune serum (previously mixed and allowed to stand for ten minutes, so that the corpuscles may be fully sensitised) is added, and the mixture re-incubated as before. In a positive reaction the complement is absorbed in the first incubation, and there is no hæmolysis. In a negative one it is not absorbed, and dissolves the corpuscles, which are sensitised by means of the rabbit serum. The results are the same as those shown on the preceding table, except that there are no indeterminate results, the conditions for hæmolysis being always present unless the complement has been absorbed in a positive reaction. This method is extremely simple and appears to give very good results.[1]

[1] For fuller details, see *Lancet*, September 3, 1910.

Wassermann's reaction usually makes its appearance during or at the end of the primary stage of the disease : approximately half the cases give a reaction before the appearance of the secondary symptoms. In the secondary stage it is almost constant—in fact, some observers have actually obtained 100 per cent. of positive results, although in most series there are a few negative findings in undoubted cases. Subsequently to this, much depends on the efficacy with which the case has been treated. As long as the disease is causing actual clinical manifestations, the reaction persists, and the same is true if it is merely lying latent. When, however, the patient has had a thorough course of treatment and the disease is completely eradicated, then the reaction disappears. According to some observers vigorous treatment may cause the reaction to disappear, but without accomplishing a complete cure, as shown by the fact that it may reappear after a few weeks' cessation of the treatment. In fact, the mere presence of mercury in the blood may abolish (temporarily) a positive reaction.

A positive reaction is known to occur occasionally in diseases other than syphilis, but the conditions under which it does so are not ascertained at present. It appears to be present frequently in leprosy and in some tropical diseases due to protozoa (frambœsia, sleeping sickness). Apart from this it has been described as occurring in other diseases, such as scarlet fever (but not constantly, and only for a short time) ; but many of these results were obtained in the early days, before the technique of the reaction had been fully worked out. At the present time it is extremely rare to find a positive reaction in a case in which syphilis can be excluded.

Hence the following rules for the interpretation of the Wassermann reaction may be given :—

(1) In the (supposed) primary stage a positive reaction is conclusive of syphilis : a negative reaction is inconclusive, but is more and more suggestive the longer the doubtful lesion has been present.

(2) In the (supposed) secondary stage again a positive reaction is conclusive : a negative reaction renders the diagnosis extremely improbable, except in the very early stages.

(3) In the later stages, if there are active clinical manifestations, there will almost certainly be a positive reaction : hence if a patient with a supposed gumma react negatively the diagnosis is probably wrong.

(4) The presence of the reaction is always an indication to continue treatment. The absence of a reaction, especially if it occurs on several occasions at intervals of a few weeks and after mercurial treatment has been suspended for at least three months, indicates that the disease is completely eradicated.

(5) Congenital cases react like acquired ones, and the reaction may persist into adult life.

PREPARATION OF VACCINES.

As a general rule the use of a vaccine prepared from cultures derived from the pus or other morbid material of the patient to be treated will be found to give better results than a stock vaccine; this is especially the case with organisms such as streptococci, gonococci and B. coli, which differ widely amongst themselves. In other cases, such as infections with staphylococci and pneumococci, the need is not so great, and treatment may well be commenced with a stock vaccine made from several strains of the organism. But if this fails the vaccine treatment should not be condemned until an autochthonous vaccine has been used.

The method by which these vaccines are prepared is not difficult, though it is somewhat tedious and requires the closest attention to details, more especially in regard to those necessary to ensure sterility of the final product. The following is the process usually employed.

Preparation of the Culture.—This is made from the pus, blood, etc., on ordinary bacteriological lines, and, in general, agar is used as the culture medium: additions such as that of sterile blood in the case of the gonococcus being made, when necessary, to adapt it to the requirements of the particular organism. It is desirable, if possible, to use the primary culture, since many bacteria lose their virulence rapidly when cultivated on artificial media, and virulence of the culture is an essential factor for a good vaccine. If the primary culture (*i.e.* that inoculated with the material from the patient) is not pure, a second one is inoculated from colonies of the organism in question: it is advisable not to make this second culture from a single colony, since organisms vary greatly amongst themselves, even in a pure culture, and it might happen that the colony selected was one of a relatively non-virulent form. When time is an object the primary culture may be used, even if not quite pure, provided that the organisms are non-sporulating (and so easy to kill) and non-pathogenic or of feeble pathogenicity. A few colonies of staphylococci, the most common contamination, do not interfere with the use of the vaccine at all, except in regard to the dosage.

The culture should be as young as possible. In the case of rapidly growing organisms such as staphylococci and B. coli, cultures 18–24 hours old should be used. In dealing with organisms such as gonococci, which grow more slowly, older cultures must necessarily be used, but in no case should incubation be continued when a good growth has developed.

Preparation of the Emulsion.—One to ten cubic centimetres of sterile normal saline solution (the exact amount is not of importance) is added to the agar culture by means of a sterile pipette, and the growth scraped off with a sterile platinum loop. The emulsion, thus formed, is shaken gently so as to break up the colonies as far as possible, and allowed to stand for a few minutes so that any large masses may settle. The saline solution must be absolutely sterile. If an autoclave is at hand, it should be raised to 120° C. for half an hour. Reliance on mere boiling is unwise, unless the water used in the preparation of the saline solution is known to be free from sporulating bacteria, as is usually the case with the water-supply of most English towns.

The emulsion thus prepared is pipetted with a sterile pipette into a sterilised test-tube, thoroughly shaken, and the sample required for counting purposes removed. The bulk of the vaccine is then sterilised.

Sterilisation of the Vaccine.—The middle of a sterile test-tube is thoroughly softened in the flame, and the two ends are pulled apart so that the softened portion is drawn out to form a narrow tube about ⅛th in. in diameter. It is allowed to cool, and the emulsion is poured in, and got into the lower portion of the tube by alternately warming and cooling the latter, so as to expand and contract the air which it contains. The narrow portion of the tube is now sealed in the flame, and, when cool, the bulb containing the vaccine is inverted and warmed in the hand, so as to make sure that the seal is a sound one, no fluid being expelled: if a drop comes out the tip must be resealed.

This hermetically sealed tube of vaccine is now attached to a weight and completely immersed in a water-bath kept at 60° C. If a thermostat at this temperature is not at hand a large beaker of water will answer perfectly, the desired temperature being maintained by the application and removal of a small flame, such as that of a spirit lamp. In this case it is a good plan to attach the tube of vaccine to the bulb of the thermometer by means of an indiarubber band, of course taking care that no part of the former is out of the water.

The period of heating is usually one hour. Some organisms are killed more quickly than this, but it is well to be on the safe side until some experience is attained as to the amount of heat necessary in the case of the organism in use. In general the less the vaccine is heated the better, provided it is sterile.

Counting the Emulsion.—While the tube is being heated the preparations, which should have been made at an earlier stage, may be counted and the calculations made. The methods of counting or otherwise determining the richness of the emulsion are numerous, but here only Sir Almroth Wright's will be described. It consists in comparing the number of bacteria in the vaccine with the number of red corpuscles in human blood, this having been previously estimated by means of the hæmocytometer. Numerous slight modifications of the process are in use, and that given will be found efficacious.

A Wright's pipette, such as is used in the determination of the opsonic index, is prepared by softening the centre of a piece of glass tubing in the flame and drawing it out into a tube about as thick as a steel knitting-needle, or rather thinner. This is broken in the centre, so as to give two capillary pipettes each attached to a wider portion of tubing, on which an india-rubber nipple is slipped. A unit mark is made with grease-pencil about 1 inch from the tip and the apparatus is ready for use. The operator then winds a narrow bandage round one of the fingers of his left hand so as to congest the tip, and makes a small puncture with the sharp point of a piece of capillary tubing just drawn out in the flame and, therefore, sterile. By bending the finger a drop of blood is squeezed out, and enough of this to reach exactly to the unit mark is sucked into the pipette. This is withdrawn from the blood and a little air sucked in. The emulsion is well shaken and this also is sucked up to the unit mark in the tube, thus giving exactly equal amounts of the two fluids. These are expelled on to the surface of a clean slide and thoroughly mixed. Films, which must be thin and even, are prepared from the mixture: there must be no delay about this, or the blood may coagulate. These films must then be fixed and stained by some method which will show both the bacteria and the red corpuscles: Jenner's method may be used, but it is better to fix with a saturated solution of perchloride of mercury and stain with carbol-fuchsin.

These films are then examined microscopically and a count is made of the number of red corpuscles and of bacteria seen in the same field of the microscope. It is necessary to count many of these fields (since the spreading is never quite even), so that a reasonably accurate estimation of the ratio of the two objects may be obtained: and these fields should be taken from all regions of the film.

The calculation of the number of bacteria in the emulsion is then simple. Thus supposing 20 fields were counted and found to contain 720 red corpuscles and 200 bacteria, and then, having found that the blood contains 5,200,000 red corpuscles per cubic millimetre, the calculation is as follows:—

For each red corpuscle there is $\frac{200}{720}$ bacteria.

1 cubic millimetre of blood contains 5,200,000 corpuscles.

$\therefore$ 1 cubic millimetre of emulsion contains $5{,}200{,}000 \times \frac{200}{720}$ bacteria $= 1{,}400{,}000$ (about)

And 1 cubic centimetre contains 1,400,000,000.

If it was desired to prepare a vaccine containing 100 millions per cubic centimetre it would be diluted with thirteen times its volume of diluent. If 1000 millions were required in one cubic centimetre, then ten volumes of the emulsion would have to be diluted with four volumes of diluent, and so on.

Testing the Sterility of the Emulsion.—The hour having elapsed the bulb of vaccine is removed from the fluid, and the tip is sterilised in the flame and broken off with a pair of sterile forceps. A little of the fluid is then expelled on to the surface of agar or other suitable medium, and the culture tube replugged and incubated. Unless it remains sterile the vaccine must not be used.

In cases of great urgency the experienced bacteriologist, who is sure of his technique, may omit this step in the case of some organisms, and thus shorten the process by twenty-four hours or more.

Preparing the Dilutions.—The emulsion is diluted with normal saline solution, containing a certain amount of some antiseptic, of which carbolic acid seems to answer best. Its strength will vary according to the amount to be added to a given volume of the vaccine, so that the final product should contain $\frac{1}{4}-\frac{1}{2}$ per cent. Thus in the example given, if the emulsion were to be diluted thirteen times, $\frac{1}{4}$ per cent. would be used for the diluent. In the second case, where four volumes were to be added to 10 per cent. of the emulsion, the fluid used might contain 1 per cent. of carbolic acid to start with, giving a final strength in the vaccine of, roughly, $\frac{1}{3}$ per cent. These dilutions are made in sterile test-tubes, and the amounts may be conveniently measured by the use of an ordinary all-glass hypodermic or exploring syringe. The vaccine is now finished. It may be kept in bulk in sterile test-tubes or bottles, or, preferably, may be put up in sealed bulbs or ampoules, each containing one dose. A hypodermic syringe may be used for filling these bulbs, which are then hermetically sealed in the flame.

SUGGESTIONS FOR DOSAGE OF VACCINES.

The following suggestions are offered as a rough guide as to the dosage of vaccines, in case no opsonic control is used. As a general rule the doses will be smaller in the more acute and severe cases, larger in the chronic ones; where very small doses are given the interval between them may be less than if large doses are employed, and in any case the clinical symptoms must be closely watched, so that any indication as to size of doses and length of interval may be obtained.

Staphylococci.—Dose 250–1000 millions at intervals of 10–14 days. Some give smaller doses, but they are probably not so efficacious.

Streptococci.—In septicæmia, erysipelas, and other acute and severe infections 5–25 millions every 4–7 days. In more chronic cases the dose should be small to commence with, but may go up to 100 millions or even more.

The use of anti-streptococcic serum must not be forgotten.

Pneumococci.—In acute cases 5–25 millions may be given every 4–7 days, or oftener, if the clinical signs seem to justify it. In chronic cases the dose may gradually rise to 250 millions or even higher, and the injections be made every 7–10 days.

Gonococci.—Good results have been obtained in ordinary gonorrhœa as the result of one or two doses of 10–50 millions: there is a general tendency towards a reduction of the dosage. In the vulvo-vaginitis of children the dose should be 1–5 millions. In gonorrhœal arthritis it is usually advisable to increase the dose up to 500 millions or even more : 5 or 10 millions may be given to commence with, and successive doses given every 7–10 days.

Bacillus coli.—The initial dose may be 25–50 millions, increasing to 250 millions at intervals of 7–10 days, or as the clinical signs suggest, though, as a rule, not oftener. The use of a vaccine prepared from the patient himself is usually necessary.

When an unknown or unrecognised organism is isolated from a lesion (as is not very infrequently the case), it is necessary to proceed with caution as the bacterium may be a very irritating one and a very small dose only advisable. It is best to give not more than 5 millions to commence with. If there is no local or general reaction within twenty-four hours a larger dose, say 25 millions, may be given.

THE DIAGNOSIS OF BACTERIAL INFECTIONS BY MEANS OF THE OPSONIC INDEX.

When the last edition of this work was issued it was generally thought that useful information as to the dosage of vaccines and of tuberculin might be obtained by periodical observations of the opsonic index, *i.e.*, the power of the serum of the patient to aid phagocytosis as compared with that of a normal person acting under the same conditions. This idea is now almost abandoned. The estimation of the opsonic index is, however, useful at times in the diagnosis of bacterial infections in which it is impossible to obtain material from which the infecting organisms can be obtained and identified. The method used for the estimation of the index is that given by Dr. Whitfield in the last edition, with one or two alterations.

Method of Observation.—Normal blood from any individual is dropped from a prick in the finger into a vessel containing 0·5 per cent. sodium citrate in normal saline. This is then centrifugalised so that the corpuscles washed free of their serum lie at the bottom, the top layer of the deposit being rich in leucocytes. It is advisable to mix the deposit with normal saline and to repeat the centrifugalisation, so that all trace of serum may be removed. About a quarter of the deposit is then drawn off and thoroughly mixed up, so that there may be a fairly even distribution of the leucocytes contained in it. This mass of red blood corpuscles rich in leucocytes is habitually spoken of as ' leucocytic cream.' Secondly, a sample of blood from the patient to be examined is allowed to clot and the clear serum is drawn off. As a matter of fact this sample is generally taken some hours beforehand in order to get the serum. Thirdly, an emulsion is made of the bacillus in question. Equal quantities of these are taken in a pipette, thoroughly mixed and then incubated at blood heat for twenty minutes. The mixture is then blown out of the pipette and again mixed, and film preparations are made from it and appropriately stained. At least a hundred leucocytes are then counted and the number of bacilli ingested by each is noted, so that an average may be worked out of the number of bacilli ingested by a leucocyte. This is then compared with the number obtained in an exactly similar experiment carried out with serum of a person known to be of the normal standard, and the result expressed as a decimal fraction of that which is taken as the normal. Thus a patient suffering from furunculosis may be found to have an opsonic index of 0·5 to staphylococci though he may have an index of 1·0 to tubercle bacilli. It is necessary that a normal control be worked out with each set of sera to be tested, as the bacillary emulsion cannot be made a constant factor, and probably the leucocytes also vary in activity, so that it is only by using the same 'cream' and the same emulsion that accuracy can be obtained. The leucocyte cream should be used as fresh as possible, in order that the leucocytes may be alive and active, but this will last at least an hour and probably much more.

The method is especially useful in the diagnosis of tuberculosis, in cases in which it is impossible to obtain material in which a search for the bacillus can be made, and in which the other methods of diagnosis which depend on hypersensitiveness to tuberculin are contra-indicated. In general terms it may be stated that the range of the opsonic index to tubercle in healthy persons or in persons suffering from disease other than tuberculosis is between 0·8 and 1·2, as compared with the average of normal persons, taken as 1. Indices, therefore, which lie between these figures are inconclusive one way or the other. Indices which lie above or below these limits raise a presumption that the disease is tuberculosis, and, the further they are removed from the normal, the more trustworthy is the diagnosis: thus, an index of 0·75 would be suspicious only, whereas one of 0·5 would be practically conclusive, and the same is true for indices of 1·25 and 1·5 respectively.

When the index lies between the normal limits and yet the diagnosis of tubercle seems probable, advantage can be taken of the fact that a minute injection of tuberculin, not enough to cause an obvious reaction, or massage of the area of the lesion (which is supposed to cause 'auto-inoculation' and let loose some tuberculous products) causes more or less characteristic alterations of the opsonic index, which usually falls and then rises to a higher level than that at which it stood previously. To make use of this test a series of observations of the index must be taken, and the effect of one of the procedures mentioned studied. If the index remains practically constant throughout, a diagnosis of tubercle is unlikely: if it varies greatly, and especially if a 'negative phase' followed by a rise occurs, the patient is probably tuberculous. It is claimed that this method will enable the observer to say that a lesion which was known to be tuberculous is cured: if the index remains constant in spite of massage or of use, it is supposed that the bacilli in the region are destroyed or are at least no longer in a state to produce toxins.

The opsonic index can also be used to diagnose infections other than tuberculosis. The index of the serum is worked out against cultures of the organisms which experience shows are probably concerned, and that with which the serum deviates most from the normal figure is found. Or a series of indices may be taken before and after massage or exertion of the affected part of the body, cultures of all the likely bacteria being used. It is undoubtedly possible to diagnose the causative organism in this way, but the labour is great. Further—and this is a point which must be constantly borne in mind in interpreting the results of opsonic determinations—the process is a most difficult one, and requires much patience and a great amount of technical skill for its successful performance. For this reason opsonic methods should only be used when the diagnosis cannot be made otherwise, and it is of vital importance that the nature of the disease should be recognised at once. In children (up to the age of fourteen years) the cuti-reaction or von Pirquet's reaction, is in every way preferable, whilst in adults there are few cases in which the subcutaneous injection of old tuberculin will not give results which are much more certain and which are obtained more quickly, and with a minimum amount of risk.

TUBERCULIN IN DIAGNOSIS.

Tuberculin, after a long period of disuse (in this country at least) has recently rapidly gained favour both as a diagnostic and as a therapeutic agent. This is largely owing to a fuller knowledge of the substance and its action, and partly also to the discovery of new methods in which it can be employed. It is now realised that, given proper care, tuberculin can be used in diagnosis without danger, and yields results which are, in many cases, absolutely accurate.

In children the most useful diagnostic method is that based on the fact (discovered by von Pirquet) that the application of old tuberculin to the skin of tuberculous patients causes a local inflammatory reaction which may go on to vesiculation ; whereas in normal or non-tuberculous, persons it has no such action. This is called the *cuti-reaction* or *von Pirquet's reaction.* It is carried out much in the same way as an ordinary calf-lymph vaccination, old tuberculin, preferably undiluted, being used instead of the lymph. An area about a quarter of an inch in diameter is lightly scarified by any suitable instrument, which should not be too sharp : the object is to remove the surface epithelium down to the corium, but not to draw blood. A drop or two of old tuberculin is rubbed well into this area and allowed to soak in. It is important that it should not be rubbed off before this has happened, and it is a good plan to protect the area with a vaccination shield or watch-glass (applied with strapping) for an hour or so. It is advisable, but not absolutely necessary, to perform a control scarification, using equal parts of glycerine and water instead of the tuberculin. In a negative case little or nothing will be seen in either area next day. If a positive reaction occurs, the area to which tuberculin has been applied will become more or less severely inflamed. In the mildest grade of reaction there is redness and swelling of the scarified area, which appears as a flat red papule. In the next grade these appearances are not limited to the area to which the tuberculin has been applied, but spread for some distance in all directions. In the most severe reactions there is, in addition to this, vesiculation of the area scarified; the control inoculation should show practically nothing.

The reaction is almost absolutely trustworthy in children up to the age of twelve or fourteen, the only exception being in those suffering from general tuberculosis or tuberculous meningitis, in whom the tuberculous infection may be so severe that the reacting power is lost: in my experience this rarely happens until so late in the disease that the diagnosis is not for a moment in doubt. The reason why the test is not satisfactory in older people is that tuberculous infections of a mild and latent type are extremely common in early life, and they appear to sensitise the tissues for many years after they are completely healed. But a very marked reaction *usually* indicates a recent infection, even in an adult.

Other forms of applying the test, such as *Calmette's*, in which diluted tuberculin is dropped on to the conjunctiva, where it causes a conjunctivitis, mild in the majority of cases, but sometimes very severe, are in use. They are not to be recommended, and Calmette's test (though it gives good results as regards the diagnosis) should not be employed because of the danger to sight which it entails.

The diagnostic use of tuberculin by *subcutaneous injection* should be reserved for those cases in which the cuti-reaction is inapplicable, and in which no morbid material in which a search for tubercle bacilli can be conducted can be obtained. Using small doses it is probably devoid of danger except in cases with severe secondary infections, especially in phthisis. In surgical affections it may, as a rule, be applied without hesitation except perhaps in cases of deep sinuses and abscesses contaminated with bacteria other than the tubercle bacillus. It should not be used where the temperature is irregular, nor in cases where there has recently been hæmoptysis. Cardiac and renal diseases are also considered to be contra-indications.

As regards dosage, there is as yet no uniformity of opinion, but the general tendency has been to reduce the amount given and to give several injections of gradually increasing doses. My own practice is to begin with $\frac{1}{1000}$ c.c. of old tuberculin, and, if this causes no reaction, to go at once to $\frac{1}{250}$ or $\frac{1}{500}$ c.c., and to regard anything as negative in which there is no reaction after this amount. Most recent writers give somewhat less than this: Bandelier and Röpke recommend a series of $\frac{1}{5000}$, $\frac{1}{1000}$, $\frac{1}{200}$ and $\frac{1}{100}$ c.c., and this may be taken as erring, if at all, on the side of caution.

The reaction consists of two parts, the general, and the focal: there may be a third, the needle-track reaction.

The *general reaction* consists in a rise of temperature, usually coming on between four and thirty hours after the injection. The height of the temperature varies, but nothing under 1° F. over the previous maximum can be regarded as significant, and it may be very much higher than this. The usual symptoms of fever are also present.

The *focal reaction* is most important in that it serves to indicate the region affected with tubercle. It consists of an inflammatory swelling of the lesion, which may be observed directly (in the case of lupus, etc.) or indirectly, by its pressure effects on surrounding structures.

The *needle-track reaction* is not always seen. It consists of an inflammatory reaction at the area of injection, commencing in the subcutaneous tissue and often spreading to the skin, forming a red spot with sharply outlined edges. It is less important than the general and focal reactions.

TUBERCULIN IN TREATMENT.

The curative value of tuberculin is undoubted. There are, however, numerous limitations to its action as at present understood, and a careful selection of cases is necessary if good results are to be obtained. Its use is not indicated if the diseases is directly amenable to surgical measures, *e.g.* excision. Thus a small area of lupus occurring on a part of the body hidden by clothing should be excised. Again, it is difficult to cure lesions in which there is a large mass of caseous material or much fibrosis: good results are occasionally obtained with tuberculous glands, but this is the exception, and as a rule it is better to remove them. But in cases in which operation is not practicable or advisable, or has to be deferred from any cause, tuberculin should certainly have a trial.

The method in which it acts is not precisely known. According to Sir Almroth Wright a main factor in its action is the increase in the amount of opsonin in the serum (already alluded to), which is supposed to increase phagocytosis and thus facilitate cure. There are theoretical objections to this explanation, and it is found as a matter of fact that persons with a low opsonic index not uncommonly do extremely well. A more important factor is probably to be found in the focal reactions which occur after each injection. These flood the tissues with blood and may also cause a profound alteration in the metabolism of the cells. If too severe, these focal reactions may go on to necrosis: this occurred with the rapidly increasing doses used in the early days of the treatment and accounts for the disrepute into which it fell. One of the main endeavours of the surgeon using tuberculin should be to avoid as far as possible any *obvious* reaction, either local or general. The slight reactions desired are inappreciable except in rare cases such as tuberculosis of the iris. A third action is probably the production of antituberculin or other defensive antibodies by which the patient is rendered more or less immune to the toxins and other products of the tubercle bacillus.

The forms of tuberculin which have been introduced are numerous in the extreme. Koch's *old tuberculin* consists of the broth in which tubercle bacilli have been grown, evaporated to one-tenth of its bulk. It is the most potent and probably the most valuable form of tuberculin, but its use requires more care than most of the other preparations. *T.R.* contains the bodies of the bacilli themselves in a fine state of subdivision. It is less potent than old tuberculin, and should be used in cases in which there is fever. It is easier to use than old tuberculin, but it is also decidedly less efficacious, and where it is used in the commencement of a course of treatment it may be advisable to go on to the other form subsequently. *Bacillary emulsion* contains the bodies of the bacilli themselves, and probably also some old tuberculin. *P.T.O.* (Perlsucht-tuberculin-original) is tuberculin prepared from bovine tubercle bacilli by a method analogous to that used for old tuberculin, but not concentrated. It is less toxic than the latter substance, and may be used for the commencement of a course of treatment.

All forms of tuberculin have to be diluted before use, in the earlier stages of the treatment at least. Sterile normal saline solution should be used as the diluent, and $\frac{1}{4}$ per cent. of carbolic acid or lysol should be added to prevent subsequent bacterial contaminations. The dilutions should be made in sterile test-tubes, and a hypodermic syringe may be used to measure the various fluids required. It is very important to notice that the diluted fluids soon lose their potency, and should not be used more than four days at the utmost after being prepared. It is especially necessary to bear this in mind in working up to high doses, otherwise sharp reactions may be caused when a fresh and potent supply of tuberculin is used after some that has become inert.

The methods of giving tuberculin fall under three main types.

(1) *The Opsonic Method.*—Here minute doses (sometimes so minute that it is difficult to believe that they have any action) are given, the intervals between the doses and the amounts in each being regulated by frequent observations of the opsonic index, an attempt being made to keep this at a high level for as long a period as possible. The results of this laborious procedure do not justify the amount of work which it entails, and the method is generally abandoned.

(2) *The Use of Small Doses at Long Intervals.*—This is a kind of

modified opsonic method, the doses and intervals being about those which are usually found desirable when the method is controlled by the examination of the blood. In general terms the doses are $\frac{1}{1000}$ mgr. of T.R. or less and the intervals seven to ten days, attention being paid to the symptoms and the length of time during which the patient seems to benefit after each injection. Good results may be obtained in this way, and no harm can result: it is, however, being rapidly given up in favour of the intensive method, in which the amount of tuberculin is gradually increased.

(3) *The intensive method* should be preferred in all cases in which the patient can be kept under constant observation. In the earlier stages it is not altogether advisable for out-patients, but when doses of some size have been reached, the difficulties are less and the intervals between the doses longer, and a patient who can be seen twice a week may be treated in this way. It is necessary that an accurate record of the temperature should be kept, and it is also advisable to observe the pulse and the patient's weight, a progressive loss of the latter being an indication that the remedy is unsuitable or is not being properly applied.

The doses are given at first at intervals of two or three days, and it is not as a rule desirable to go much longer than this or hypersensitiveness may ensue. In the later stages when large doses are reached, the interval increases, and the maximum amounts may be given at weekly intervals, or even more.

The commencing doses of the various preparations will depend to some extent on the general health of the patient and on the presence or absence of fever, but in general terms may be stated as follows:—for old tuberculin, $\frac{1}{10000}$ c.c. or less; for T.R., $\frac{1}{1000}$ mgr.[1]; for bacillary emulsion, $\frac{2}{1000}$ mgr.; for P.T.O., $\frac{1}{10000}$ c.c.

Each dose is larger than that which preceded it, the idea being to increase the amount given as quickly as possible consistently with the avoidance of reactions. In general terms each dose may stand to its predecessor in the proportion of 3:2, *i.e.* each may be half as much more as the previous one, but this is only a rough rule, and each case has to be considered on its merits. Bandelier and Röpke give as an example the following series: $\frac{1}{100000}$ c.c. of old tuberculin, $\frac{3}{100000}$ c.c., $\frac{6}{100000}$ c.c., $\frac{1}{10000}$ c.c., $\frac{2}{10000}$ c.c., $\frac{3}{10000}$ c.c., $\frac{5}{10000}$ c.c., $\frac{7}{10000}$, $\frac{1}{1000}$ c.c., $\frac{1{\cdot}5}{1000}$ c.c., $\frac{2}{1000}$ c.c., $\frac{3}{1000}$ c.c., $\frac{5}{1000}$ c.c., $\frac{7}{1000}$ c.c., $\frac{1}{100}$ c.c., $\frac{1{\cdot}5}{100}$ c.c., $\frac{2}{100}$ c.c. $\frac{3}{100}$ c.c., $\frac{5}{100}$ c.c., $\frac{7}{100}$ c.c., $\frac{1}{10}$ c.c., $\frac{1{\cdot}5}{10}$ c.c., $\frac{2}{10}$ c.c., $\frac{3}{10}$ c.c., $\frac{5}{10}$ c.c., $\frac{7}{10}$ c.c.,

[1] In the preparation of T. R. 10 mgrs. of tubercle bacilli are used for 1 c.c. of the ultimate product, and the amounts quoted are calculated as if this were all present in the material as sold. As a matter of fact 1 c.c. only contains 2 mgrs. of dried substance, and unnecessary confusion has resulted from some writers, who calculate their doses in this way, stating their doses as one-fifth of those given on the old system for identical amounts. Bacillary emulsion contains 5 mgrs. in 1 c.c.

1 c.c., which is the usual maximum dose in cases that do well under the treatment.

The maximum dose of T.R. may be taken as 20 mgrs. (or 2 c.c. of the original fluid: this costs 17*s*., which renders it an expensive remedy). The maximum dose of bacillary emulsion is said to be 10 mgrs., and of P.T.O. 1 c.c., after which a more potent preparation is used.

But no hard and fast line as to the sequence of the doses can be laid down, and in each case a careful study of the patient's temperature and other symptoms is necessary. If there is any noticeable reaction it is advisable not to increase the dose, but to administer the same after the fever has subsided: this may be necessary more than once, and the amount must not be increased until this dose causes no reaction. A reaction obtained after a moderate increase is in general an indication that the patient is highly susceptible and is an indication to increase the doses slowly. Bandelier and Röpke's list is mainly applicable to phthisis, and in surgical tubercle in which the lungs are unaffected the increases may often be somewhat more rapid, and an occasional reaction need not cause alarm.

The injections should be made into the subcutaneous tissues of the arm, back or flank, and the degree of local reaction, if any, round the site of injection carefully noticed. Occasionally this is somewhat severe and may be an obstacle to further progress, necessitating very slow advances in the dosage. If much redness and swelling are produced hot fomentations may be applied.

Tuberculin has been given by the mouth and does not appear to be entirely devoid of action when administered thus. But the amount absorbed is uncertain, and the advantages of the method are not apparent, whilst its disadvantages are obvious: in any case, no attempt to administer large doses in this way must be made.

INDEX

END OF VOLUME I.

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